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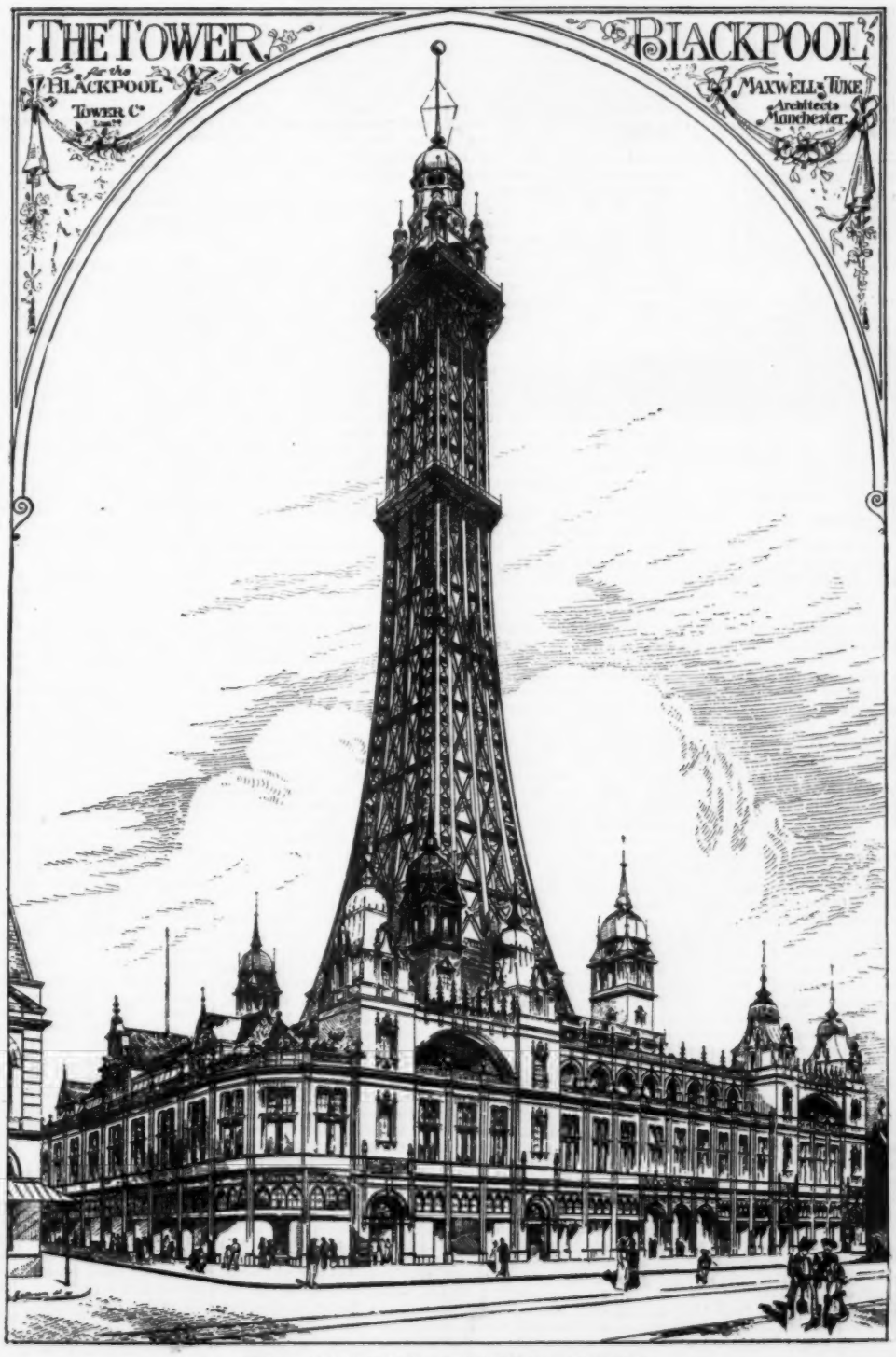
THE LONDON EIFFEL TOWER.

THIS design, by Messrs. Maxwell & Tuke, Manchester, has been chosen in the late competition, and the new buildings are to be erected upon a plot of land containing about 6,000 square yards, bounded on the westerly side by the central beach and on the other sides by Bank Hey Street, the principal street approaching the town from the central station, by Victoria Street, and by a narrow street on the south side. The position is the most central in Blackpool, being midway between the north and south piers, and within 150 yards of the central station. The plan of the new building will be almost rectangular in form, with a tower 100 ft. square in the center. The base of this is to be used as a circus, with four entrances from the central beach and Bank Hey Street, besides performers and horse entrances from the narrow street. On the right and left of the circus are large arcades for the sale of toys, jewelry, and other fancy articles. Each arcade will have six entrances, three being from the central beach and three from Bank Hey Street. The space between these important thoroughfares will be traversed by eight broad passages. The outside portion of the ground floor facing the three principal streets will be devoted to shops. The first floor will be occupied by the circus gallery, and the remainder of the floor by the menagerie and aquarium, which will be reinstated on this floor by an attractive waxwork exhibition, and by popular exhibitions of varied kinds either permanent or annual.

The second floor will be a spacious promenade concert room and floral hall, with an area of nearly 30,000 square feet, with two stories of open-air balconies and cafes facing the sea. The Eiffel Tower, between 400 ft. and 500 ft. high, will stand in the center of the plot. It will be 100 ft. square at the base, and will be reduced to 30 ft. square at the foot of the cupola. The first or grand gallery, 70 ft. above the level of the ground, will consist of an inclosure 80 ft. square, with an open balcony surrounding it 18 ft. wide, and at this level the lifts from the ground floor will terminate and the central lifts to the summit will commence. This inclosed hall will be fitted with shops for the sales of refreshments, confectionery, photographs, and other fancy articles, and with cafes raised several feet above the level of the gallery outside.

The second gallery, 300 ft. above the level of the ground, will comprise an inclosed hall 30 ft. square, where the lifts will terminate, and in order to accommodate the crowd of visitors expected to be conveyed by the lifts, there will be five open galleries above this, containing about 27 ft. square in each, and one open gallery 36 ft. square with a double staircase so arranged that the visitors can only pass in one direction. By these means the directors hope to accommodate as many as 20,000 passengers in one day, which is a very important consideration in a place like Blackpool, where as many as half a million visitors are registered as visiting the town in one week. The lantern and cupola, in which it is intended to place an electric search light, will rise about 50 ft. above the uppermost galley, and will be approached by a narrow circular staircase.



THE LONDON EIFFEL TOWER.

The means of access to the upper floors of the building and to the tower will be very commodious. For persons desirous of ascending the lifts, the large central hall, with entrances from the beach, will be arranged on the ground floor, with a service of hydraulic lifts to carry visitors to the first or second floors of the building, or to the great gallery in the tower, 70 ft. above the level of the ground. If visitors desire to go higher than this, they must be transferred into one of the central lifts, traveling from this to the second gallery, 300 ft. higher, whence they can ascend still higher by means of ample stairs to any of the six galleries overhead, of which mention has already been made.

In addition to the above mentioned lifts, ample provision is made for staircases leading to the different floors and to the summit of the tower. The first and second floors will be served with three staircases, each 10 ft. wide, and four staircases each 5 ft. wide. The broader staircases will stop at the level of the promenade concert room, but the four narrower stairs will be carried to the level of the great 70 ft. gallery. When the buildings are being cleared of visitors these stairs will be equivalent to a staircase 50 ft. wide, which would enable 35 persons to march out abreast. It is intended to construct the tower of wrought iron and steel, but in order to make the fullest provision against the contingency of fire, the 16 great legs will be formed with square iron lattice pillars, filled and clothed with Portland cement concrete of a decorative character, with the light iron lattice work showing between. Besides giving great security in the event of fire, the additional weight of the concrete legs will afford immense stability against wind pressure, which is a power to be carefully considered in Blackpool. The materials intended to be used for the fronts are red brickwork, with terra cotta dressings of a somewhat elaborate character. The buildings will be lighted throughout by electricity, which will be produced by machinery in the basement. The cost of the buildings is estimated at £120,000 or $600,000.—*Building News.*

JET PROPULSION.*

THE following contribution to the subject will, I hope, be of interest. It needs but little introduction, since, to a great extent, it explains itself. A year or two since, when the subject was a live one in certain quarters, several students took special interest in the mechanical principles involved, when we came to them in the course of instruction. I laid down the law, as usual, enforced it by illustration and argument, but it so happens that these principles, like many other good ones, are unacceptable to the unregenerate mind. When, therefore, I learned that some had gone away and quietly tried the thing, I experienced one of those moments of satisfaction which come to every successful laborer in a good cause. I was glad that nature had had the chance to vindicate her own laws. The subject is not one which is, ordinarily, well understood; in fact, many engineers are totally wrong in their conception of the way in which a jet acts, and it will be a satisfaction to me if this letter contributes toward a more correct knowledge of the facts.

April 12, 1891.

DEAR SIR: The following is a description of some experiments which I made with water jets in the fall of 1889, to prove that the reaction of a jet is the same in air as in water.

These trials were made to disprove a statement that a stream of water issuing from a nozzle under water reacts upon the surrounding water and tends to drive the nozzle in the opposite direction to that of the jet, in the same way that a solid rod, issuing from the same nozzle, would react upon a stone wall. I felt certain as to the results of the experiment, because *you* had told me what they would be beforehand.

The arrangement for measuring the reaction is shown in the accompanying sketch on next page.

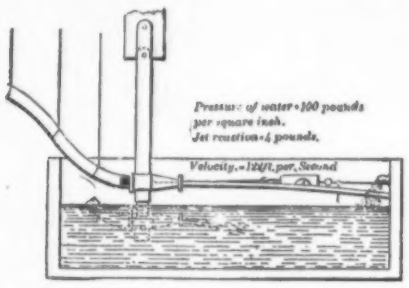
The tests were made in a large tank, and the water was supplied by a steam pump at a constant pressure of 100 pounds per square inch. The pump had a steam cylinder of four inches, and a water cylinder of two and three-sixteenths inches diameter, and a stroke of two and a half inches.

* Paper read by J. Burkitt Webb before the Providence meeting of the American Society of Mechanical Engineers.

The nozzle was fastened to the foot of a pendulum four feet long and connected to the pump by a flexible half-inch rubber hose. The hose was hung by strings, so that the stiffness was inappreciable. The pendulum at the nozzle was connected to a spring balance by a cord about four feet long. When the jet was flowing the pendulum was brought to the vertical by moving the balance, and in this way every force due to the deflection of the pendulum was eliminated. The pendulum was first hung so that the nozzle was a little above the water, and the reaction found to be four pounds. The pendulum was then lowered so that the nozzle was about four inches below the surface of the water, all other conditions being the same, and the reaction was found to be the same—four pounds. The only difference was that when the nozzle was under water, the balance hand vibrated a little more.

When these results were reported to the party making the statement, the rejoinder was made that "the reason was that the jet struck the opposite side of the tank"—five feet distant—"and so pushed back on the nozzle."

I, therefore, measured the reaction in air again with the pendulum hung from the roof of the house, twenty-five feet above the ground, so that the jet broke into spray before it struck. All the conditions were the same as before, and the reaction was the same—four pounds. I then put a flat plate on the pendulum, and let the jet impinge upon it, and the pull was the same as the reaction—four pounds. I afterward used a



similar apparatus (but more delicate) with a constant head of water—about ten pounds per square inch—from an elevated tank. The only difference from the first trial was that the pendulum was held in a vertical position by a delicate spring balance when the jet discharged in the air, and then nothing was altered, but the water allowed to rise in the tank until the nozzle was two inches below the surface, and the balance reading remained *absolutely the same.*

I hope these results may be of some service to you, and thanking you for your kindness and instruction while I was at Stevens Institute, I remain,

Truly yours, CHAS. J. EVERETT, JR.

DISCUSSION OF THE PAPER.

Mr. C. W. Nason.—I would like to ask Prof. Webb, in regard to the duty of the engine or pump, whether there is anything more in it than merely the pressure?

Mr. Webb.—The horse power is equal to the reaction of the jet multiplied by the velocity of the jet. It is equal to the momentum of the jet. It is equal to the reaction multiplied by the space through which it acts.

Mr. Nason.—The pounds and pressure to the square inch, both multiplied by the velocity?

Mr. Webb.—No; that will not give it.

Mr. Nason.—It is the quantity of water, then, in pounds, multiplied by the velocity?

Mr. Webb.—The pounds pressure to push the vessel ahead is equal to the number of pounds of water per second, divided by the gravity, which gives the mass, multiplied by the velocity with which it issues. There is an interesting fact with reference to the reaction of the jet. Suppose at first the vessel is closed up, and you have a pressure of 100 pounds per square inch in the side of the vessel. If you open it, it relieves the vessel 200 pounds. A hole in a vessel, where there is a pressure of 100 pounds greater than outside, a one-inch-square hole open, will make a difference of 200 pounds on that wall of the vessel inside; 100 pounds because the wall is cut away and another 100 pounds because the pressure on the rest of the wall decreases.

Mr. G. C. Henning.—I should like to say a few words in regard to this. It is so plain that even the ordinary inventor can understand it. The other day I had occasion to look into this matter, because an inventor who wanted $40,000 for experimental purposes to prove that he was right, came to me with a proposition to build a boat in which the water left the orifice just as fast as the boat went ahead. Then, of course, the action and reaction would be equal. Of course, he believes with all of us that Dr. Jackson's theory, as illustrated in his beautiful little boat down at South Brooklyn, that the water issuing at a very high pressure acted like a steel rod against a solid wall, was all wrong. He said he had experimented upon his model in a keg of water. He had his model in there, and then he measured the speed of the water and the speed of the boat, and he found that the water moved just as far as the boat did. Hence he obtained the greatest efficiency, because he had the water to resist all around, and the action on the water and the action on the boat were equal, because the velocity of the water and the boat were equal, while, of course, he could drive his boat with any speed. It is a very pretty way of reasoning. But as soon as his attention was called to the fact that if there was any commotion in the tank beyond the starting line of the boat, why, then, the water must have gone just a little bit beyond that line from the new position of the boat. Hence, the velocity of the water was equal to the number of feet from the new position of the boat to the point at which the commotion was stopped in the tank, while the velocity in the boat was read by the number of feet passed over from the starting point to the new position of the orifice.

Mr. Henry H. Suplee.—It was my fortune to experiment to increase the efficiency of a screw propeller by surrounding it with a converging nozzle. The experiments were made on a little naphtha launch about twelve to fifteen feet long, and a propeller fifteen inches in diameter. The nozzle was made with a cross jacket, so that the water would flow into it. It fitted entirely around the propeller, so that the water was drawn in by the propeller, and discharged through the tube. When the boat was moored fast to the wharf, and a swing balance inserted similar to the experiment described by Prof. Webb, it showed a marked increase in the pull on the swing balance when the tube was used. It seemed as if the propelling power of the propeller was decidedly increased. In some cases it ran up as high as twenty-five to thirty per cent. When the boat was loosed, and we endeavored to see the increase in the speed, there was a marked loss, as great as ten or fifteen per cent., which was apparently due to the increased resistance of the rods, etc., in the water. So that, while it gave a steady pull, it gave a very marked reduction in velocity.

Mr. M. F. Wheeler.—I have just come into the room, so that I have not had the benefit of all this discussion, but I would like to make a practical observation here. Some reference was made to a boat constructed in South Brooklyn on the principle of the jet, in which the inventor was more than sanguine in regard to the success of it. I always contended that, even if he secured the effect which he expected to with his jet, he could never practically apply it to vessels, for the simple reason that he has got to use a pumping engine. It is a well known fact that the piston speed of a pumping engine is very limited. In direct acting machines it is about one hundred feet. In the fly wheel machines it has been increased to 350 and even 400 feet. But what is that against the modern marine engine that makes from 800 to 1,000 feet? The practical application of that would be that the engine would be so very bulky and heavy, to say nothing about its lower rate of economy in steam, that you could not practically apply it for modern navigation; in other words, that the rule required for a pumping engine for this jet propulsion, provided the jet was a success, would be so great that you could not practically apply it with any success. Then, again, you would require more boiler capacity for the reason that we do not get so great economy with pumping engines as we do with other types of engines.

Mr. W. W. Bird.—I should like to ask one question. That is, if the jet was thrown into a vacuum, what would the reaction be then?

Mr. Webb.—I will say that the object of this paper was not to give all that could be said upon the subject, because one might write a book, taking up the way it appears to different people, and correcting all the errors. The object was to put something in a shape that can be understood—as Mr. Henning said, and I thank him for the compliment in saying that this thing can be understood—to prove that the reaction is the same theoretically and practically. The reason why a jet should do more in going into the air than in a boat is that, when it goes in the boat, it creates a current in the water, and makes more friction. I think, if I understood Mr. Henning's remarks aright in reference to this inventor's plan, it was that he was to have the jet leave the vessel at the same speed as the vessel.

Mr. Henning.—Yes, sir; the water moved back at the same speed.

Mr. Webb.—That is a most excellent plan. That will give one hundred per cent. efficiency, and the machinery is the simplest in the world. All you have to do is to put a straight tube right through the vessel, and then the water will enter and leave at the same speed, and there will be no loss, except friction, and you can get a canal horse or something else to pull the vessel along. That is the way in which all these schemes have been carried out. This high speed jet was propelled by talking mostly. Now then, with reference to a remark by Mr. Suplee. If the propeller in an ordinary ship is surrounded by a tube—we won't say a conical tube, but let it be a parallel tube—it will prevent the power going to the radial velocity. Therefore, if we could put a tube around the propeller, and have no friction in that tube, we would gain something; but the friction in the tube probably would not be the element that would bring the speed of the vessel down. In reference to some other remarks as to the impossibility of running a vessel by a jet on account of using a pumping engine, why, every steam propeller is run by a jet. It is only a different kind of pump. A propeller is a pump then, to give the velocity backward; and the only difference between them and these schemes for running a small jet is that the propeller is large enough to propel the boat, and the jet is not, and the propeller runs at as slow a velocity as possible, and, therefore, gets a higher efficiency. Now, as to the discharge into a vacuum. It does not matter what it discharges into, no more than when you shoot a gun, it does not matter what you shoot at; if the gun kicks, it will kick. At the same time, if you plug the gun up it is not likely to let the ball go out. Consequently, reduce the pressure all the time outside the vacuum, and the more you reduce it, the greater the velocity of the escape will be. All the action done in giving the velocity to the water after the jet has gone an inch or so from the vessel makes no difference; you can put a board right up against the back of the vessel, provided you don't put it near enough to decrease the area of the whole of the jet. This principle occurred to me when the Charleston was sent after the Itata. If the two vessels were able to steam at about the same speed, and the former had nearly caught the latter, and they then commenced firing at each other, the reaction of the guns would be a case of "jet propulsion;" that is, the reaction or kick of the Itata's guns, firing backward, would increase her speed, while the forward firing on the Charleston would retard her, and prevent her from overtaking the Itata.

THE torpedo boats, Nos. 126 and 127, supplied to the French government by Mr. Normand, gave a speed of 10 knots, and used only 1·04 lb. of coal per hour per horse power. At full speed, No. 129, the last delivered, with a pressure of 10 kilos. in her boilers, consumed, under the same conditions, 800 grammes only (1 lb. 12-21 oz.) M. Normand attributes his success to greater evaporization in the boilers, complete compression in the small cylinder, reheating of the feed water, and superheating the steam by narrowing the valve. The following were the speeds attained at the official two-hours' trials: No. 126, 21·087 knots; No. 127, 20·695 knots; No. 128, 20·975 knots.

THE ROYAL MAIL STEAMER SCOT.

THE new twin-screw steamer Scot, of the Union Steamship Company, which we illustrate, was built by Messrs. William Denny & Bros., Dumbarton, and has passed through a series of progressive trials on the Clyde and an extended trial at sea with excellent results as regards speed and sea-going qualities. The Scot went on her builder's trial on May 15, when she steamed over the measured mile at a speed of 19·78 knots with the tide and 19·46 knots against it. Eleven days later she was subjected to a more interesting yet more crucial test for speed, and on that occasion the measured mile was covered not less than six times, thrice with and thrice against the tide, at full power, the mean of the whole six runs resulting in a speed of 19·17 knots, and of the last two runs 19·225 knots. On May 29, a prolonged run was made on the Firth of Clyde, when the same high average speed was easily maintained. The day following the Scot left the Clyde for Southampton, the powerful machinery working throughout with great smoothness, and vibration was entirely absent. The speed guaranteed by the builders was 18·5 knots on a mean draught of water of 23 ft., and this speed was exceeded on the second trial by 0·67 of a knot under conditions of wind and weather which were not conducive to obtaining maximum results.

The Scot has been specially constructed for mail and passenger service, and will be the largest as well as the fastest vessel running between this country and South Africa. The usual time taken to perform the passage is about 17½ days, although the record of the Dunottar Castle is just under 16 days. The powerful machinery of the new liner, however, will enable her to cover the 6,000 nautical miles between Southampton and Cape Town in a little over 14 days.

The new vessel is built entirely of steel on the cellular bottom principle, and her dimensions, which approximate to those of some of the fast Atlantic liners, are as follows:

Length over all	500 ft.
Length between perpendiculars	460 ft.
Breadth moulded	54 ft. 6 in.
Depth "	37 ft. 6 in.
Gross tonnage	6,884 tons.

Her external appearance is quite captivating. She is lightly rigged with two pole masts, and is provided with two large oval shaped funnels, while her graceful lines terminate forward in a clipper stem embellished with a handsome figure of Sir William Wallace. The stern is superbly adorned with carving, aptly designed to suit the name of the ship. The shell plating is double-butt strapped on the top sides and bilge, and particular attention has been devoted to the stern structure, which is built of great strength to withstand the enormous strains engendered by the use of such powerful machinery as the Scot is fitted with. The brackets carrying the screw shafts, each of which weighs ten tons, are of cast steel. The rudder is made so that it can be readily shipped or unshipped without necessitating the vessel being placed in dry dock.

The hull is subdivided transversely by fourteen water tight bulkheads, ten of which are carried to the upper deck. All the bulkheads are made specially strong, and so arranged that if any two compartments should ever be in free communication with the sea the vessel would still remain afloat. Because of the experience gained by the accident to the City of Paris, the central bulkhead which usually divides the two sets of engines has been omitted in the Scot. Of decks there are five, including the promenade deck, the latter extending over a length of 257 ft. Forward and aft there are short wells, which in each case is bridged by a gangway connecting the promenade deck with the forecastle and poop respectively, thus practically making one continuous deck. The bridge, wheelhouse, chart room, and captain's apartments are all built above the promenade deck. Accommodation has been provided for 212 first-class passengers, 104 second-class, and 108 third-class; while to meet the possibilities of a growing emigrant service, provision has been made whereby the steerage can readily be rearranged and the quartering of third-class passengers largely increased. The first-class passengers are berthed forward, and the public rooms set apart for their use are lavishly decorated and upholstered. The most palatial apartment is the grand saloon, which is situated in the upper deck forward of the boiler spaces, and has dining accommodation for 190 persons. Adjoining the saloon, at its after end, are the first-class pantries, bar, cooks' quarters and kitchen, together with their necessary offices. The music room is situated above the grand saloon. At the fore end of the music room entrance is obtained to the ladies' boudoir, a handsome apartment upholstered in relief velvet, the paneling being hand painted. Beneath the grand saloon is a spacious children's saloon and state rooms for first-class passengers. The smoking room measures 30 ft. square, and can be approached either under shelter from the main deck or in the open from the promenade deck in fine weather.

The second class passengers' quarters are located in the after part of the vessel under the poop. The dining room is a spacious apartment, ranging the whole breadth of the vessel, neatly paneled in polished ash, and furnished with a piano, library, etc. From the saloon a winding staircase leads to the promenade on the poop deck above, on which is situated a comfortable smoking room. Below the dining saloon there is an auxiliary saloon with state rooms adjoining, the accessories of the latter being in every way similar to those found in the cabins allotted to first-class passengers.

The third-class quarters, which are reached by a separate staircase from the upper deck, are situated aft on the main deck, the dining and cabin accommodation being of a superior description to that usually found in passenger steamers. To the comfort of both seamen and firemen special attention has been devoted. The former are housed in comfortable quarters under the forecastle, and provided with a separate galley and washing house for their own use, while the latter are berthed between the engines and boilers on the main deck, and are also provided with a washing house and a galley, to which is attached a special lift constructed so that their food can be passed below without crossing the upper deck. In every detail the convenience of the passengers has been carefully stu-

died, the culinary arrangements being of the most complete description.

With regard to the sanitary contrivances, the ventilation has been so carefully considered that it may be said the ventilating arrangements of the Scot are as near perfection as science and mechanical forethought will permit. The baths are of solid marble, each being provided with hot and cold water sprays, while the lavatories are of special design and fitted with wash-out hoses for frequent cleansing in hot weather. Six fans driven by electric motors are utilized for the purpose of ventilating the passenger accommodation on the main deck, and collectively are capable of renewing the air five times in an hour. In addition, two downcast fans are placed in the electric engine room, and two Blackman's air propellers are fitted in connection with the main engine room. The latter are of sufficient capacity to completely change the atmosphere of the engine room twenty times during an hour.

The Scot is lighted throughout with the electric light, fitted by the builders. Not fewer than 680 incandescent lamps of 16 c. p. have been utilized throughout the ship, and the necessary current for the same is obtained from three compound wound 100 volt dynamos, supplied by Messrs. King, Brown & Co., Edinburgh. Each dynamo is driven by a separate engine running at about 200 revolutions per minute, and is capable of supplying current for 300 lamps. Large lead colored leads are carried from the main switch board to the auxiliary switch boards, which number fourteen, placed in different parts of the ship. The dynamos which supply the power for the electric lighting of the ship also drive the ventilating fans.

In the equipment of the Scot particular care has been given to the life saving appliances. Ten of the sixteen boats carried are life boats, and four are Berthon's patent collapsible boats of the largest size, each of which is capable of seating seventy persons. The steering arrangements are of a very perfect description—in fact, it is doubtful if a steamer exists which is better equipped in this respect, there being not less than five different methods by which steering may be accomplished, and, further, should the whole of the various methods be disarranged at any one time, perfect control of the vessel could still be maintained by the manipulation of her twin screws.

The Scot is fitted with two sets of triple expansion engines by Messrs. Denny & Co., capable of developing collectively about 12,000 h. p., the diameter of the cylinders being as follows: High pressure, 34½ in.; intermediate, 57½ in.; and low pressure, 93 in., the stroke being 60 in. We hope to illustrate and describe these engines in a later issue. Steam is supplied at a working pressure of 170 lb. per square inch from six double ended steel boilers, arranged in two compartments. The boilers have been constructed to meet the requirements of Lloyd's registry and the Board of Trade, each boiler being fitted with six of Fox's patent corrugated furnaces, 44 in. in diameter, and Martin's doors. The stokeholds are ventilated by twelve large cowls, and no forced draught is provided for the boilers, but a notable departure has been made in adopting funnels of extreme length, namely, 120 feet high above the grate bars. This arrangement has proved eminently satisfactory.

The whole of the steel propeller shafting and the propellers were supplied by Messrs. Vickers & Co., of Sheffield.

The enterprise of the Union Steamship Company in placing such a magnificent vessel as the Scot on their Cape service will, no doubt, be much appreciated by the traveling public.

The above particulars are from *Industries*. We are indebted to the *Engineer* for our engraving.

WOODEN BRIDGE OVER THE RIVER BARROW.

A WOODEN bridge on a novel principle was recently erected by Colonel Weldon, of Earlsmount, Earley, near Reading, over the River Barrow, at Kilmorony, Kildare. We give in Fig. 1 a general view of the bridge as erected, from which it will be seen that the structure consists of ten spans, supported on pairs of raking struts forming the piers. The spans are each 15 feet in length. In Fig. 2 we show a detail of one of these piers. The struts there shown are 9 inches wide by 3 inches thick, and from 16 feet to 20 feet in length, and are provided with shoes at their lower ends. The cross girder consists of two planks 18 feet long by 11 inches by 1⅛ inches thick, connected by bolts passing through six wooden distance pieces 4 inches thick between the timbers. The central four of these distance pieces project beyond the girder, and serve to secure the four longitudinals or stringers on which the roadway is carried, but this detail is not shown in our illustration. The stringers are 16 feet long by 7 inches deep by 3 inches wide, and the roadway, which is 10 feet wide, consists of 3 inch planking. The principal

FIG. 1.

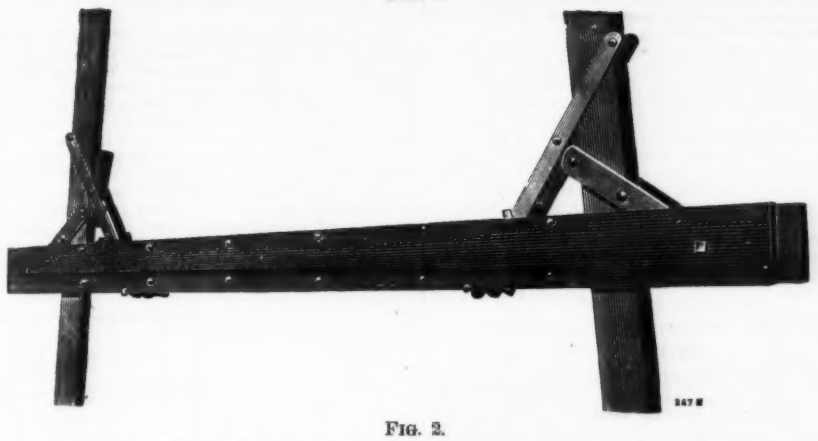
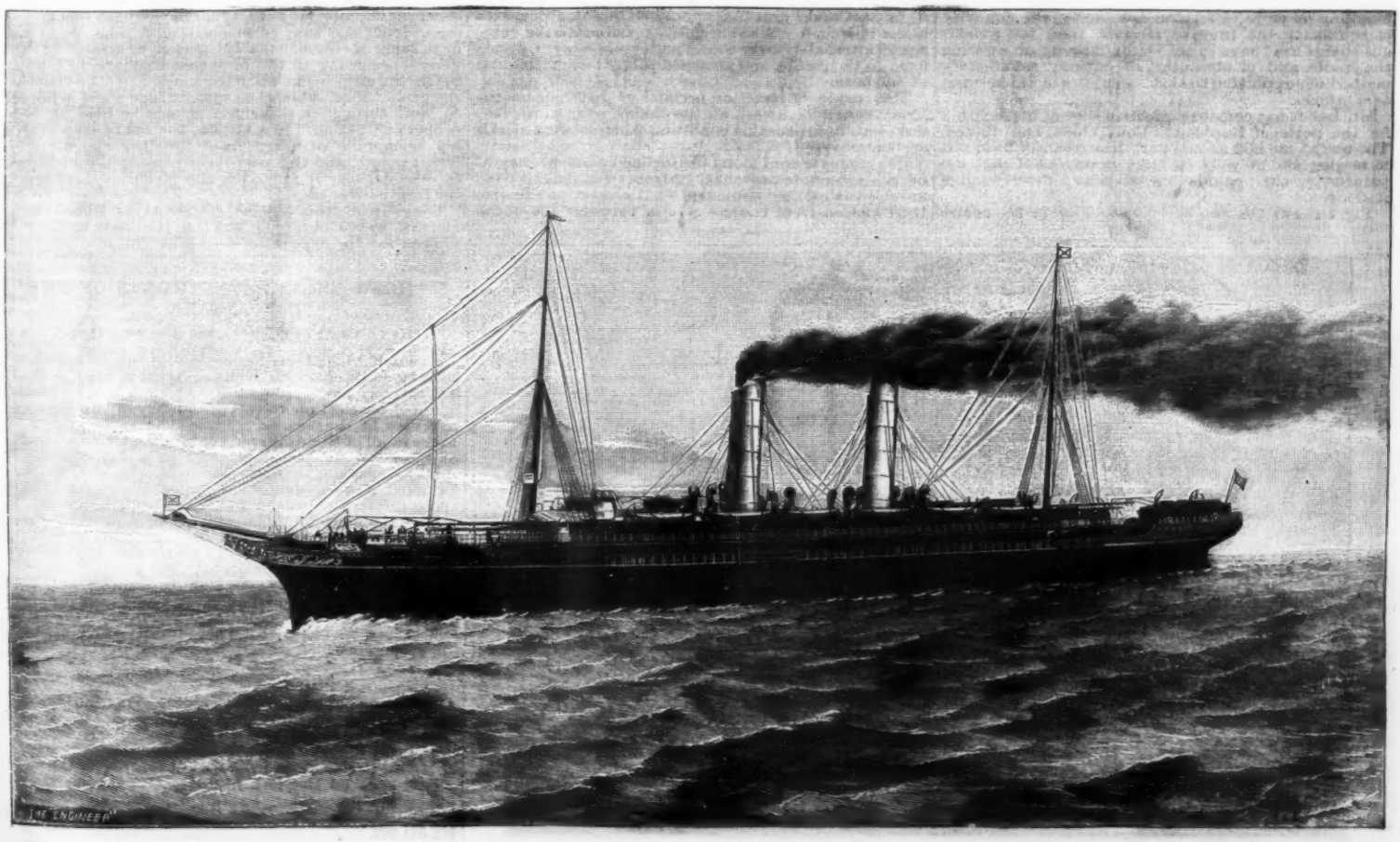


FIG. 2.

WOODEN BRIDGE OVER THE RIVER BARROW.



THE NEW STEAMSHIP SCOT.

novelty in the bridge is the method of securing the cross girders to their supports. This is done by the levers shown in detail on the left of Fig. 2. It will be seen that the grip is purely frictional, while the device is remarkably simple, consisting of but a couple of levers and a wedge. By withdrawing this wedge the cross girder can be moved freely up and down the strut, but once this is in place the frictional grip is such that no downward motion of the girder can occur, and a perfectly firm support is obtained for the roadway. Such a bridge is very easily erected. In this case a couple of balks were placed athwart the gunwales of a boat; on these was placed the cross girder on its side. The struts were then slipped through the levers and the wedges driven in so as to secure the struts to the girder near their shoe ends, care being taken to give them their proper inclination to each other. The boat was then floated to the required spot, and moored there. The struts were up-ended and the wedges loosened, allowing them to slide down through the levers to the bottom of the river. The longitudinals were then secured by means of a length of wire rope passing through a hole in them to the projecting distance pieces of the cross girder, after which rope tackles were fastened to the tops of the struts and the girder hoisted up to its proper level. The wedges were then replaced and driven home, securing the cross girder firmly in place. The bridge was tested on its completion by passing over it a load of 35 cwt. on two wheels drawn by a horse, and has been ever since regularly used for cart traffic. Since its erection it has withstood severe floods and heavy gales without developing any sign of weakness. The employment of a frictional grip for securing the cross girders seems very advantageous, as no skilled work is required in the erection. The levels can be adjusted with the greatest ease. Only four laborers, all of whom were totally unskilled, were employed in its erection, completing it after only thirty hours' work, which is good time for a bridge across 150 feet of water. The total weight of the structure is but 7½ tons, and its cost was but £48 1s. 4d., made up as follows:

	£	s.	d.
Woodwork	13	9	5
Flooring and pulleys	14	3	6
Ironwork	11	18	4
Carriage	5	0	0
Wages of carpenter for girders	1	10	0
" four laborers for 30 hours in erection	2	0	0
Total	48	1	3

In designing this bridge Colonel Weldon had in view the necessities of military service. Such a structure could be readily transported and rapidly erected. —*Engineering.*

SLIP FOR THE BROADWISE DOCKING OF SHIPS.

UP to recent years, but three means have been employed for the docking of ships preparatory to repairs to the hull: the use of graving docks, into which the vessel is floated, and whence the water is removed by means of powerful pumps; of floating docks, metallic apparatus composed of horizontal caissons, upon which the ship is placed while they are sunk to the bottom of the basin, and which are raised again by pumping out the water contained in the tight chambers of the caisson; and, finally, of inclined planes, up which is drawn a cradle carrying the vessel. Mr. Labat, of Bordeaux, has taken up the idea, already old, of hauling up ships broadwise, an arrangement that had already been employed for boats of small tonnage, but which, up to the present, had not been extended to the handling of large vessels, on account of the difficulty of equalizing the tractive stresses upon the numerous chains that have to act for hauling up or lowering the cradle, and of obtaining an entirely satisfactory method of supporting the load upon the inclined plane as a whole.

Mr. Labat has constructed three slips of his devising for the ports of Bordeaux, Fou-Tchiou, and Rouen. The one at the last named port has recently been put in service, and as it is the most improved of such apparatus, we shall confine ourselves to a description of it alone.

Fig. 1 shows the slip carrying a ship in the course of repair; Fig. 2 gives a transverse section, and Fig. 3 shows the maneuvering of the shorage bolsters that permit of lowering the vessel on the blocks.

The slip of the port of Rouen comprises three parts —the inclined plane, the cradle, and the tractive apparatus. It is 90 meters in total length, and is capable of receiving vessels 95 meters in length and having a weight of 1,800 tons. It consists of 42 string pieces supporting steel rails and resting upon piles tied to each other in a longitudinal direction (Fig. 2). The slope is 20 to 100, and the width in the hauling direction is 31·3 meters. The travel of the cradle is thus 36·5 meters, which corresponds to a vertical elevation of 7·16 meters, sufficient for the needs of the port. It can be traversed in five, three and a half, or two hours, according as the machinery is geared for a small, medium or great velocity.

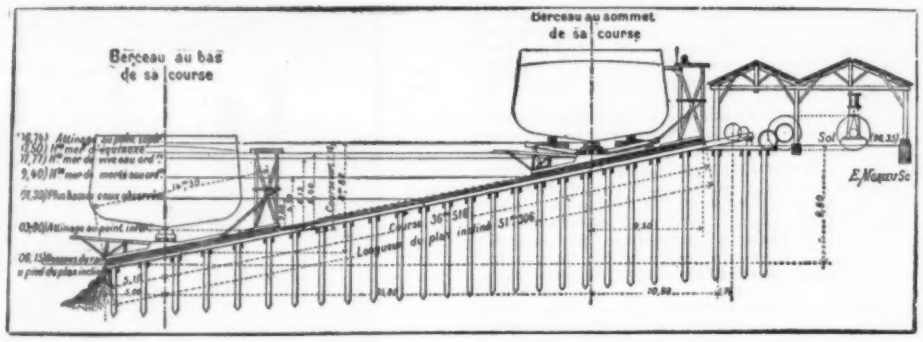


FIG. 2.—TRANSVERSE SECTION.

The cradle is divided into two parts, respectively 49·36 and 40·44 meters in length, which may be mounted together for docking large and medium sized ships or may be utilized separately for small ones. It is formed of twelve girders, A, very strongly crossbraced, that correspond to the string pieces of the inclined plane. Each girder carries a steel rail beneath it. Between this rail and that of the corresponding string piece are interposed a series of rollers over which the cradle moves. The length of each of these is equal to that of the latter increased by half the length of the distance to be passed over. They are actuated by small iron wire cables, fixed on the one hand to the cradle and on the other to the framework of the ship, after passing over a pulley. On the land side the cradle is provided throughout its entire length with a foot bridge high enough to remain always out of water. Forty chains are attached to the cradle between the intervals of the girders. They are not fixed directly to it, but act upon movable pulleys sliding in grooves 0·2 meter in length. What is called a compensating cable passes alternately over these pulleys and over others fixed to the cradle, and attached to the two extremities of the latter.

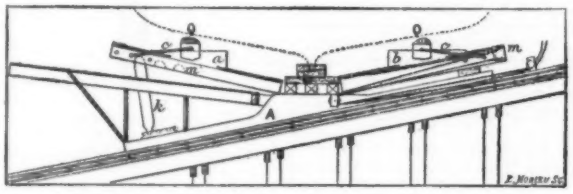


FIG. 3.—TRANSVERSE SECTION OF CRADLE.

This mode of traction permits of distributing the stress equally between all the chains, so as to prevent jerks—an indispensable condition when so great masses are maneuvered.

The chains ascend along the inclined plane in sheaths narrow enough to prevent them from twisting, and wind around the toothed drums of windlasses which receive their motion from endless screws through the intermedium of gearings. These screws, the use of which permits of obtaining ease of operation in the transmissions, are themselves actuated, through bevel wheels, by a shaft extending throughout the whole extent of the slip.

The motor is of 50 effective horse power upon its main shaft.

Mr. Cadart, government engineer at Rouen, from whom we borrow our data and illustrations, considers this slip as an excellent docking apparatus, because it realizes a satisfactory support of the movable cradle upon the inclined plane, an equal distribution of the tractive stresses between the various chains, great regularity in the motions, and, at the same time, unusual facilities for the propping of ships.

It remains for us to speak of this operation, which presents some interest. The cradle being in the lower position (Fig. 2), the ship to be repaired is floated over it in such a way that its keel shall take a position over the plane part that receives the blocks. Stays arranged against the foot bridge permit of keeping it in this position. Afterward the cradle is raised until the keel rests upon the blocks, where it is temporarily wedged up. The fixing of the ship in a lateral direction is effected by means of movable cushions, Q (Fig. 3), which operate in series of two and are displaced under the action of wedges sliding upon iron plate girders, *m m*. These wedges, *a* and *b*, are capable of being moved in either direction by means of chains maneuvered by windlasses established upon the foot bridge. Moreover, they are connected by rods with the girders, *m m*, and are capable of undergoing but a slight vertical displacement, as is the case with the cushions that they support.

It results from this that the latter rest gently against the ship and are always easily disengaged. As, on another hand, the motions must be reduced to a minimum when the ship is in position, it is necessary to have some method that shall permit of arranging the wedges according to the lines that they are to follow before the ship is put upon the blocks. To this effect, the girder upon which the lower wedge slides is jointed, and, through a stanchion, *k*, may be held at the proper inclination. In addition, the rod of each cushion is capable of being fixed to the girder at different points, and this permits of causing the cushions to recede from or approach the blocks, according to the form of the ship.

The slip of this system employed at Rouen cost $148,000, $8,000 of which was for the earthwork and the rest for the apparatus itself.—*La Nature.*

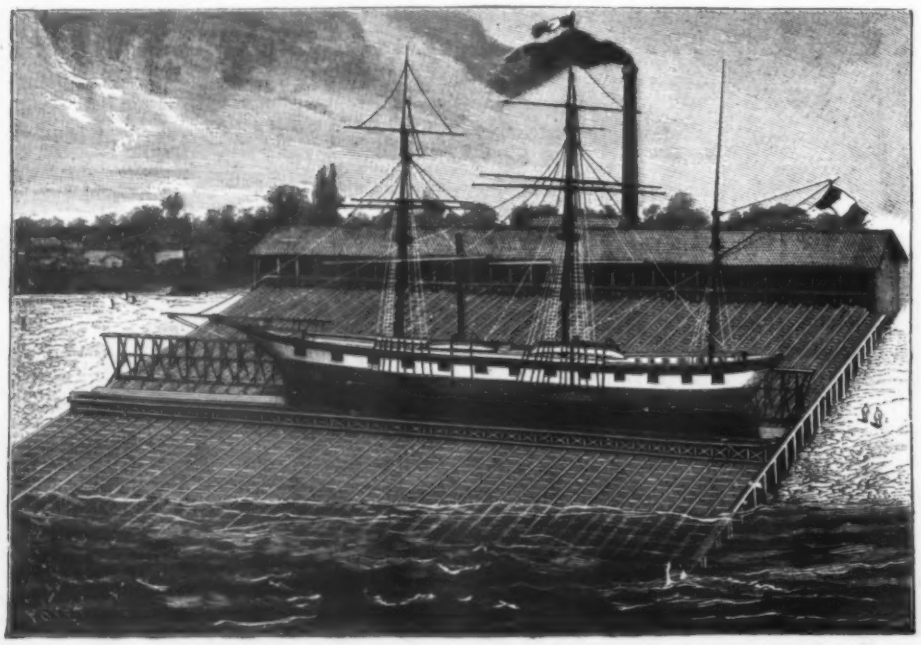


FIG. 1.—SLIP FOR THE BROADSIDE DOCKING OF SHIPS.

LEADING ENGINEERING WORKS OF THE PAST YEAR.*

By O. CHANUTE, President Am. Soc. C. E.

THE field of engineering has now grown so large and is being cultivated in so many different directions that it is scarcely practicable for the member who has been honored by election to the presidency of this Society to review in the annual address the engineering advance in all of these different directions, for an attempt to do so would probably result in a dry catalogue, chiefly consisting of numerical data. In fact, having gathered a good deal more information than I can make interesting within the time at my command, I shall not undertake upon this occasion to present to you a review of the whole field, and the members present will thereby be spared a good many indigestible statistics which I have collected; but I shall endeavor instead to select a few of the leading engineering works of the past year, to touch upon the new things and the advance which they indicate upon previous practice, and to interest you with an account of some engineering proposals which seem to possess features of novelty.

THE CROTON AQUEDUCT.

The principal engineering achievements during the past year have been in connection with tunnels. First, there was the completion of the new Croton Aqueduct, practically a rock tunnel 30 miles long, under charge of Mr. A. Fteley, Vice President of this Society, which was opened on the 15th of July, 1890, having taken five years in boring. Its full capacity is 318 000,000 gallons per day, and its cost to June 30, 1890, was $23,561,973.

* Address at the annual convention of the American Society of Civil Engineers, at Chattanooga, Tenn., May 22, 1891.

THE ST. CLAIR RIVER TUNNEL.

Next there was the successful driving through of the railroad tunnel beneath the St. Clair River at Sarnia, under charge of Mr. Joseph Hobson, member of this Society; an achievement which seems likely to inaugurate a period of considerable activity in similar works in this country. You will remember that tunnels under rivers have hitherto been believed to involve almost insuperable difficulties, that a similar work was abandoned at Detroit some seventeen years ago, after considerable sums had been spent on trial headings, under one of our ablest engineers, Mr. Chesbrough, that work was also suspended upon the Hudson River tunnel at New York in 1887, because capitalists had lost faith in its successful completion, and that a good many important crossings of rivers have remained in abeyance, halting between the opposition of the marine interests to a bridge and the difficulties which were thought to be involved in an attempt to tunnel. These difficulties seem to have been so far resolved in the Sarnia and other recent tunnels that we may expect capital to be furnished freely for analogous projects in the near future.

The tunnel under the St. Clair River at Sarnia was built for the Grand Trunk Railway by the St. Clair Tunnel Company, of Canada. It is for a single track, and just 6,000 feet long between portals; 2,290 feet of this distance being under the river proper. It is driven through soft blue and gray clays, with occasional pockets of gravel and quicksand. Casual bowlders were met with, while inflammable and explosive gas, issuing through fissures, added much to the danger of carrying on the work.

THE HYDRAULIC SHIELD.

The success achieved was chiefly due to improvements in the shield, which latter was designed by Mr. Hobson; to the rapidity with which the lining could be put in place; and to the admirable organization of the work and plant. The shield was cylindrical in form, 21 feet 6 inches in diameter, 15 feet 3 inches long, and built of 1 inch steel plates. It was forced forward 18½ inches at a time by 24 hydraulic rams distributed around the circumference at the back of the shield, and taking their bearing against the completed portion of the lining. Their aggregate capacity was 3,000 tons as a maximum. The front portion of the shield is divided into twelve compartments or pockets, which form shelves upon which men stand to excavate the material in front of them, under cover of the cutting edge. This material is passed back through two doors in the lower portion of the shield, which can be rapidly closed, should the men be driven away from the front by the intrusion of soft or liquid material. After passing through those doors, the excavated material is conveyed to a dump, upon small cars running over a service track. The work was carried on night and day from each end, and was performed at normal air pressures, that is to say, with the outer ends of the tunnel open, until the edges of the river were reached. Then bulkheads were put in at these points, and the remainder was excavated in compressed air, with pressures varying from 10 to 28 pounds to the square inch, in order to keep back the intrusion of water by drying the exposed surfaces of the clay, and to support the latter to a certain extent, by increasing the air resistance.

The lining is of cast iron, 2 inches thick. The ring is 21 feet in outside diameter, and divided into thirteen segments, each 4 feet 11½ inches long, provided with flanges by which they are bolted together. Thin packing pieces of seasoned oak are inserted between the segments, which by their swelling, when in contact with moisture, produce a water-tight joint. Lengthways of the tunnel each lining ring measures 18¼ inches, and the segments are swung into place by a rotating arm or crane, which can be extended and has also a radial motion. Less than one hour sufficed to swing and bolt into place a ring of segments, and it has been done in forty-five minutes, the clay being kept back meanwhile by the projecting hood or rim, 4 feet long, at the back of the shield. When at the next forward movement this rim is slid forward, the annular space, 1 inch thick, thus left, was filled by injecting cement grout to prevent caving. The shield was controlled and kept in true line by bringing less or more of the rams into action. They were all independent of each other, and by working each of the twenty-four rams as required, the direction of the shield could be altered at pleasure. This feature proved a complete success, the work never varied more than 2 inches out of true position, and at the final outcome the two shields met exactly, under the river, both as to line and to level.

The works were lighted by electric incandescent lights and drained by pumping engines, but the precautions taken were so complete that there was very little water to take care of. As may be imagined, such an extensive and care-compelling piece of work required a good deal of machinery. This was admirably arranged, chiefly in groups at each end of the tunnel, and a visit to the plant conveyed more the impression of a well organized manufacturing establishment than that of an ordinary tunnel outfit, generally bristling with temporary expedients. There was a place for everything and everything was in its place, while every man understood clearly his duty and performed it promptly.

Excavation began in January, 1889, and the tunnel proper was started July 1, 1889, on the American side, and September 21, 1889, on the Canadian side. The two shields met on the 30th of August, 1890, thus practically occupying one year to go 6,000 feet, or at the average rate of about 8 feet per day per heading. Meanwhile, work was resumed upon a very similar plan upon the tunnel under the Hudson River at New York. The shield was designed and constructed in England, and is practically upon the "Greathead" system, which will be further alluded to hereafter. The work is now in progress and is said to be advancing at the rate of 10 or 12 feet per day through the Hudson River silt, which proved so troublesome during the previous occasion. It is understood that it has practically been decided to build a similar tunnel under the river at Detroit, in lieu of the bridge, for which a charter has been sought during the past few years; that in fact the work has been begun, so as to hold the charter, and that it is expected to complete the tunnel within two years.

THE LONDON ELECTRIC UNDERGROUND RAILWAY.

Antedating somewhat the Sarnia tunnel, a similar work, upon a similar system, consisting of the subway tunnels for the "City and South London Railway," has been carried on in London, on the designs and under the supervision of Mr. J. N. Greathead, C.E. This work extends from the "Monument," close to London Bridge, under the Thames, to a point on the Clapham Road near Stockwell, a distance of some 3¼ miles, and was opened to the public on the 4th of November, 1890. The subway is sunk some 50 or 60 feet below the surface, thus avoiding all interference with sewers, gas and water pipes, foundations of buildings, etc., and therefore reducing very greatly the land and other damages, which have proved so expensive in such city works. It consists of two separate tunnels, each 10 feet in diameter, driven through the London clay by the methods devised by Mr. Greathead. These mainly consist in forcing forward a metallic shield by hydraulic power, as fast as the material is excavated ahead, and lining up behind with built-up rings of cast iron plates, much in the way which has been described in treating of the Sarnia tunnel. The diameter being small, a forward progress of 16 feet per day was frequently obtained, and the two tunnels were kept entirely separate from each other, being generally side by side, but in some cases being one above the other.*

This division into separate subways not only reduces the amount of excavation, but it confines each train within its own tunnel, thus limiting its possible wreck if it leaves the track, and avoiding the danger of its being run into by a train running upon the other track; it also greatly improves the ventilation of this underground railway by causing each train to act as a piston and to drive out the air ahead of it.

The railway carriages are cylindrical in form, and are hauled by electric locomotives, thus suppressing the foul gases which have proved so annoying in the London underground railways now worked by steam locomotives. Inasmuch as passengers are conveyed between the street and the underground stations by elevators, the increased depth is not objectionable, and the line is actually found to be more accessible than the Metropolitan Railway, which is only half as deep, but is reached by staircases.

The electric machinery is said to be working well, and the line to be meeting with much public favor, so much so that already a considerable number of similar projects are in the field. It is proposed to provide deep subway lines for London and for New York; and a triple tunnel line for carriages and foot passengers is now in progress under the Clyde, at Glasgow.

TUNNELING NEEDLES.

Still another system of tunneling has been introduced in England during the past summer, in boring a tunnel 1,560 feet long and 25 to 26 feet in diameter, for an additional double track railway line at King's Cross Station, in London. This system is that of Jennings & Stannard, patentees, and consists in supporting the clay, while driving through it, upon iron or steel sheet piles or needles 10 feet 6 inches long, 12 inches wide and 2 inches thick, so tongued and grooved as to interlock each other, while permitting of sliding forward. These needles are driven forward into the clay, from one to three at a time, by hydraulic jacks, until but one or two feet rest upon the brick work of the finished portion. The other end is supported upon timbering, as the excavation and brick lining progresses, and the needles having a cutting edge shape the excavation to the desired section. As they are but two inches thick, no subsidence is said to take place upon their being driven forward after the lining is built, inasmuch as the thickness occupied by them is filled up with cement grouting, through tubes provided for that purpose, as fast as the work progresses. This method evidently requires but an inexpensive plant, and readily admits of changes in the size and shape of the excavation. It is not unlikely that in firm clay it may prove cheaper and more expeditious than the working with a shield, but in treacherous material the latter would seem to be much safer and more reliable.*

DRAINAGE TUNNEL—VALLEY OF MEXICO.

Reference may be made, while touching on tunnel materials, to the drainage tunnel for the Valley of Mexico, 9·76 miles long, which is now being driven through the "tepetate" of that country, and which is expected to be completed in 1892. This "tepetate" is a sort of volcanic mud, thoroughly compacted, which cuts like half-baked clay, and stands a good deal like rock until it is attacked by water and weather. It was through this material that Martinez, the Mexican engineer, performed, in 1608, the extraordinary feat of driving a drainage tunnel more than four miles long in eleven months, with impressed Indian laborers and the crudest mechanical appliances.

Some of you, at least, will remember that our fellow member, Mr. De Garay, gave us, in 1882, a most interesting account of this great work; which led, when the unlined tunnel caved and choked up, to the digging of the "Nochistongo" cut, the greatest in the world, occupying one hundred and fifty years in its monstrous excavation; and how he explained the reasons which required the boring of a new tunnel in connection with an adequate drainage canal. These works are now in progress, the tunnel excavation being supported by the old-fashioned timbering methods, which are said to answer well in this good ground.

THE TUNNEL UNDER THE ENGLISH CHANNEL.

The various tunneling methods which have so far been described are applicable chiefly to clay or firm silt, and it is notable that through this class of material the progress has generally been from 10 to 13 feet per day, no matter what was the size of the excavation or the system employed. In solid rock or in soft and porous materials, some other methods are preferable, and may be briefly touched upon. For soft rock, like chalk, remarkable results have been achieved with a machine invented by Colonels Beaumont and English, of the British Royal Engineers, in the proposed tunnel between Dover and Calais, prior to the suspension of the work some nine years ago. This machine consists chiefly in a very massive cutter head (driven by compressed air), in the shape of a single cross arm of the diameter of the heading tunnel to be cut, say seven to eight feet. It is provided with cast iron cutters, so arranged that as the edges wear they can be turned so as to present new cutting points, and it is said to bore with extraordinary rapidity. It is stated to have eaten into the chalk at the rate of a foot every ten minutes, and that upon one occasion the progress obtained on a trial was 87 feet in twenty-four hours, including the removal of the debris, or nearly seven times the best progress which has been made in clay.

It is, by the way, a fact but little known that this tunnel between England and France, which, if ever completed, is to be 20 miles long, has had a good deal of work done upon it. Not less than a mile is already bored at each end, and indeed it was whispered to some of the American engineers, when in Paris in 1889, that a good deal more than one mile was bored on the

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* President Chanute—usually most careful and accurate—is in error in attributing the origin of the system of tunneling by means of the hydraulic shield above described to Mr. Greathead, London. It is an American invention, was designed by Mr. Alfred E. Beach, of the SCIENTIFIC AMERICAN, and was patented and first used by him in 1869, in the construction of the short section of railway tunnel under Broadway, New York, extending southward from the corner of Warren Street and Broadway. The tunnel still exists and also the hydraulic shield with which it was built. This tunnel, with the Beach hydraulic shield at the head of it, was thrown open to the public in 1870, and visited and examined by thousands of people. The operation of the shield and of the whole work was officially supervised by Gen. George S. Greene, C.E., formerly president of the American Society of Civil Engineers, at that time chief engineer of the Croton Aqueduct of New York.

At that early period (1869) the need of rapid city transit for passengers was strongly felt in New York, but there was great opposition on the part of property owners along the line of the proposed railway, through fear that the buildings would be injured if a tunnel were carried on a lower level than the foundations; added to which would be serious loss of business by the closing and tearing up of the streets during the construction of the work. Mr. Beach determined to show the fallacy of both of these objections by excavating a short piece of tunnel under the most crowded part of Broadway, at a lower depth than the adjacent buildings, and without interrupting business or traffic. He accordingly constructed the hydraulic shield or underground boring machine, which he set to work, and with it constructed a tunnel extending under Broadway from Warren Street to Park Place, large enough to receive a small street railway car, the length of the tunnel being between three hundred and four hundred feet. This tunnel was 9 ft. 4 in. in exterior diameter. It was started at the head of Warren Street, from which it turned underground on a radius of about 50 ft. into Broadway. The curved portion of the tunnel was walled with cast iron plates, put up in segments and united by means of bolts; the straight portion was walled with brick masonry. The object of the shield was to protect the workmen while excavating the earth and building the tunnel.

The shield consists of a strong cylinder somewhat resembling a huge barrel with both heads removed. The front end of the cylinder is sharpened so as to have a cutting edge to enter the earth. The rear end of the cylinder, for a length of two feet or so, is made quite thin, and is called the hood. Arranged around the main walls of the cylinder and longitudinal therewith are a series of hydraulic jacks, all operated from a common pump, each jack having cocks, whereby it may be cut off from the pump whenever desired.

Within the shield are vertical and horizontal braces and shelves. When at work, the iron plates or the masonry, of which the tunnel is composed, are first built up within the thin hood of the shield, the hydraulic jacks are then made to press against the end of the tunnel plates or masonry, which has the effect to push the shield ahead into the earth for a distance equal to the length of the pistons of the jacks, say two feet, or not quite the length of the hood, and as the shield advances, men employed in the front of the shield dig out and carry back the earth through the shield. By the advance of the shield, the hood, within which the iron or masonry tunnel is built, is drawn partly off from and ahead of the constructed tunnel, thus leaving the hood empty. The pistons of the hydraulic jacks are then shoved back into their cylinders, and a new section of tunnel is built up within the hood as before described. The shield is then pushed ahead, and so on. The extreme end of the tunnel is always within and covered and protected by the hood. In this manner the earth is rapidly excavated or bored out, and the tunnel built without disturbing the surface of the ground.

The floor of the Broadway tunnel above mentioned was 21½ feet below the pavement. It was carried under sewers and beneath the Croton water mains, and its working was highly approved by Gen. Greene, the official representative of the Croton Aqueduct Department. The work was executed while the street was thronged with omnibuses and heavy teams, and few persons, except those directly interested, had any knowledge that a tunnel was in progress until after it was completed. It was then opened to the public, and many thousands of people enjoyed the privilege of riding in the car, which was worked back and forth in the tunnel by the pneumatic or air pressure system.

By means of the system of hydraulic jacks, capable of either combined or separate action, Mr. Beach was enabled to govern the direction of his tunneling shield with the utmost precision, making it to ascend or descend in the earth, according to the grade required, or travel on a curve of any desired radius. The first machine attracted much attention on the part of engineers. It was illustrated and described in the SCIENTIFIC AMERICAN of March 5, 1870, also in the *Manufacturer and Builder* of the following year, and in various other publications.

Since the construction of the Broadway tunnel the Beach hydraulic shield has been employed on a number of important engineering works with success, and it is now generally recognized as an important adjunct in the execution of various classes of underground tunnels. In London, 1886-89, the Beach hydraulic shield was adopted by Mr. J. N. Greathead, and was employed by him in the construction of the City and Southwark subways, recently opened for public traffic as the underground electric railways. These two tunnels extend from the Monument, London, and pass under the Thames River, Great Dover Street, Kennington Park road and other thoroughfares to Clapham, a distance of about three miles. The exterior diameter of each of these tunnels is 11 ft. 6 in.

The Beach hydraulic shield has also been brought into use in the railway tunnels now in process of construction under the Hudson River, between New York and Jersey City, N. J. The shields here used have an external diameter of 19 ft. 11 in.

The tunneling of the St. Clair River was carried on by means of two of the Beach hydraulic shields. Each shield was circular, 21½ feet in diameter, 12½ feet long, and built of plate steel one inch thick. Propelled by twenty-four hydraulic jacks. The hydraulic machinery for the St. Clair shields was made at the same establishment in New York that produced the hydraulic work for Mr. Beach's first shield in 1869, namely, Watson & Stillman's, formerly Lyon's. Illustrated descriptions of the Beach hydraulic shields, as used in the St. Clair River tunnel and in the Hudson River tunnel, will be found in the SCIENTIFIC AMERICAN of Aug. 9, Sept. 13, and Nov. 1, 1890.

President Chanute also conveys the impression in his address that the use of compressed air in the headings of tunnels is due to Mr. Greathead, being a part of his (Greathead's) system. But this use of compressed air is also an American idea. It is the invention of Mr. Dewitt C. Haskins, of this city, the original projector and engineer of the Hudson River tunnel, and was first used by him in the tunnel heading in 1874. It was patented in 1874. Compressed air had been used in vertical caissons long prior to Mr. Haskins' time. But he is justly entitled to the credit of the idea of using it as a stiffener and support of the earth in tunnel headings. But for Mr. Haskins, probably there would to-day be no Hudson River tunnel. The Haskins system was also used in the St. Clair River tunnel. Mr. Greathead adopted and used Haskins compressed air system in constructing the two Southwark tunnels in London, and if we may believe his testimony before the Parliamentary committee, the Haskins system, although he gave the author no credit, was of the utmost value to him in carrying those works through wet ground.

Engineers will do well to bear in mind, whenever this London Greathead "system" of tunneling is put forward, that its body and soul consists of two first class American inventions which everybody is now at liberty to use, the patents for both having expired.—Ed. SCIENTIFIC AMERICAN.

* The system of tunneling by means of supported needles arranged to slide in juxtaposition to each other, substantially as above described, is an American invention, and is shown in American patent No. 91,071, granted to A. E. Beach, June 8, 1869.—Ed. S. A.

French side; but in any event the confidence of capitalists seems to be so great in the profitable prospects of the proposed investment, at the estimated cost of $20,000,000, that they are said to be prepared to resume operations at once, if only the military objections on the part of the British government be removed. How far the machine which has been above alluded to would be applicable to hard rock might be well worth the experiment.

TUNNELING BY MEANS OF CAISSONS.

For soft, permeable and sandy soils, still other methods of tunneling must be devised, especially where, in order to maintain easy gradients, it is desirable to go but little below the bottom of a stream. For such cases the proposal has repeatedly been made to put the tunnel down from the top, by sinking a series of bottomless pneumatic caissons, end to end, and connecting them afterward together. It is evident that in that case the principal difficulty is how to make the joints or connections, and a number of ingenious devices have been proposed for that purpose. The best suggestion is probably that of applying the "Poetsch freezing process," by equipping the ends of the caissons, outside of the bulkheads, with coils of iron pipes, through which some frigorific substance can be circulated, after two adjoining caissons are in place, and soil has been dumped on top of them. The expected result would be to freeze the material surrounding and intervening between the caissons, so as to permit of driving through it, and then making a permanent connection. It is believed that this method promises considerable economy, especially in those cases where it will be practicable to dredge out a trench in advance before dropping in the caissons, as the cost of such dredging excavation would be but about one-fifth that of excavation in compressed air, or at the heading of a shield in a tunnel.

Smaller tunnels than those which have been above mentioned are also in progress for water-works at Chicago, Milwaukee, Cleveland and St. Louis, but these have been so frequently described that it does not seem desirable to do more than to allude to them on this occasion.

MARINE.

While we have not maintained on the ocean and in the foreign carrying trade the relative position which the United States occupied in the days of sailing vessels, and while the railroads have pretty well curtailed the business of the steamboats upon our principal rivers, yet we have continually enlarged our marine on the Great Lakes, both as to number and size of vessels, so that the commercial fleet thereon now consists of some 1,247 sailing vessels and 1,435 steam vessels, while ten years ago there were 1,408 sailing vessels and 868 steam vessels. The maximum size has been increased from 1,200 tons to 1,900 tons for sailing vessels, and from say 1,500 tons to about 3,000 tons for steam vessels. This increase in size has been brought about by the competition of the railroads, which have, by constantly reducing their rates, compelled the lake vessels to do the same, in order to hold their trade, greater economy in water transportation having been secured by increasing the size of the vessels, and by building them of metal instead of wood.

But increased tonnage of vessels requires increased draught and depth of water, and therefore a number of works have been carried on by the general government about the Great Lakes, which have within the past ten years increased the navigable depths from 13 to 16 feet, and which have been shown to save annually more than their entire cost to the country at large.

Many of the new steamers, which, with 15½ feet draught, can carry 2,500 tons, could carry 3,000 tons with the channels deepened to 20 feet. Their speed, although not as great as that of the transatlantic passenger steamers, may be stated at 14 to 15 miles per hour. Improvements are therefore now in progress by the building of a larger canal lock at the Sault Ste. Marie, and by deepening the channels through the St. Clair flats and at the Lime Kiln crossing at the mouth of the Detroit River, which will soon give a navigable depth of 20 feet from Duluth to Buffalo; and one of the important engineering problems of the near future is how best further to avail of the superior economy of water transportation. Three or more projects are now being contemplated and discussed by the communities surrounding the great lakes, which will be briefly outlined.

SHIP RAILWAY BETWEEN THE LAKES.

It is only when our attention is called to the subject that we realize the economy which pertains to water transportation. Mr. Corthell, member of this society, in a very able and carefully prepared paper, recently read before the Canadian Society of Civil Engineers, states the ocean freight rate at an average of ⅛ mill per ton per mile, the existing lake rate at 1⅛ mills, and the through rail rate at 5 mills per ton per mile. Thus the lake rate is three times and the rail rate ten times that of the ocean rate. Mr. Corthell favors a ship railway 66 miles long between Lakes Huron and Ontario, and the deepening of the St. Lawrence River, including the enlargement of the several side canals, to flank the troublesome and dangerous rapids which exist at various points, so as to give a clear navigable draught of 20 feet to the ocean. He estimates the cost of this at $27,000,000, and that of the ship railway at $15,500,000 more. He also estimates that the result will be to reduce the cost of freight from Chicago to Liverpool to $3.48 per ton, as against $6.74 per ton all rail to New York, and thence by ship to Liverpool. The rate over the ship railway is estimated at 3⅛ mills per ton per mile, as against 10 mills per ton per mile on the Welland Canal.

SHIP CANAL FROM LAKE ERIE TO THE OHIO RIVER.

The second project is to connect the waters of Lake Erie with those of the Ohio River by ship canal. The General Assembly of Pennsylvania authorized in 1889 the appointment of a commission to determine the feasibility of the project, and to survey and lay out a route so as to estimate the cost. This commission reported last February to the General Assembly of 1891. It recommends a route, from Conneaut harbor on Lake Erie to the Ohio River at Rochester, 103 miles long, to be extended to Pittsburg, so as to give a navigable depth of 14 feet. The prosecution of the surveys was intrusted to Mr. J. M. Goodwin, member of this society, and to Mr. Thomas P. Roberts, who were also members of the Pennsylvania Commission, and the route favored makes the distance from Lake Erie to Pittsburg 128¾ miles. The locks proposed would be 315 feet long and 45 feet wide, with 15 feet of water on the breast wall. This would afford passage for wooden, screw, freight steamers of "full" lake model to carry 1,500 tons of cargo on 14 feet of water; and for gunboats of the Concord and Yorktown class, which are 230 feet long on the load line, with 36 feet beam and a mean draught of 14 feet. The cost of the canal is estimated at about $27,000,000.

CANAL FROM CHICAGO TO THE MISSISSIPPI.

The third project provides for navigation incidentally as it were. The city of Chicago, having for sewerage purposes decided to reverse the current of the Chicago River, and to cause it to empty into the Mississippi tributaries instead of Lake Michigan, will, in carrying on its drainage operations, create a navigable channel to Joliet, some 37 miles, which it is expected shall be extended by the general government to the Mississippi River. The existing canal affords 6 feet depth, and the improved water way will probably be not less than 14 feet deep from Chicago to the Illinois River, and thence 10 feet, to be ultimately increased to 14 feet, to the Mississippi. The cost of the drainage proper, the portion which the city of Chicago is to perform, has been estimated at $20,000,000 to $28,000,000, and it has been expected that the work would be under way before now. Some complications have, however, recently arisen through the imperfect legislation which was obtained before sufficient time was taken to make an exhaustive engineering investigation of all the elements of the problem, and a fresh illustration is given of the adage that great haste may result in slow speed.

SHIP RAILWAYS.

Whether large loaded vessels can safely be transported overland, and whether the ship railway is destined to afford transit in locations where the difficulties of the ground or the scarcity of water do not admit of building a canal, we shall probably know better a year or two hence, when the Chignecto Ship Railway is in operation. This is now being built, as you know, across the Isthmus of Chignecto, in Nova Scotia, and will be the first ship railway constructed. A paper on this subject, by Mr. J. F. O'Rourke, member of this society, was published in the February *Transactions*. The line of the Chignecto Ship Railway is 17 miles long, and is straight throughout. It thus avoids the use of any floating deflection tables, such as were designed by Captain Eads for the Tehuantepec Ship Railway, two or three of which are proposed by Mr. Corthell for the Hurontario line. These are to be placed at the intersection of tangents, where the direction must be changed to avoid incurring great cost, and they are likely, if ever built, to cause delays and annoyances of various kinds. They are felt to be an unsatisfactory solution, as not only troublesome and costly in themselves, but as increasing largely the cost of grading, in order not to multiply the number of these turn tables, and the consequent loss of time.

I remember that on the profile of the proposed Tehuantepec Ship Railway there was one tremendous cut, with level ground on each side, and that Captain Eads told me that it was through an entirely isolated rocky hill, through the middle of which he felt constrained to run his line, in order to avoid putting in a deflection table, while a detour of a few hundred feet on either side would have avoided it entirely. In point of fact, as we know, nature does not lay out her work on straight lines, and flexibility is required in ship railway lines, to conform to the natural sweeps of the country. Perhaps this requirement has been met by the invention of a British engineer, Mr. William Smith, of Aberdeen, who has patented an arrangement of ship railway which is claimed to admit of both lateral and vertical movement of the trucks carrying the ship, without communicating these motions to the vessel which is being transported. He exhibited a working model of this on a large scale at the Edinburgh Exhibition of 1890, which picked up out of the canal boats 38 feet long and 7 feet 6 inch beam, transported them 1,200 feet overland, on gradients varying from 1 in 20 to 1 in 75, with curves of 95 feet radius, and dropped them back into the canal at another point. The loading occupied one and one-half minutes, and the unloading one minute, and two naval experts, Sir E. J. Reed, late chief constructor of the British navy, and Mr. W. Kiniple, expressed the opinion that by this system ordinary ships can be transported overland with absolute safety and at small cost. The car or cradle which is intended to carry the ship rests upon compound trucks, each composed of four ordinary trucks, so as to admit of motion both laterally and vertically. The cradle approximates in outline to the vessel which is to be carried, and in this cradle are placed a series of India rubber canvas bags or tubes, of about 8 inches diameter. For large vessels these may be increased to 3 feet in diameter. They are closed at one end and open at the other, being filled with water up to about flotation level, so that the vessel is constantly water-borne, and receives none of the twists nor shocks which may be encountered by the trucks. If this device succeeds on a large scale, as well as it seems to have done in the working model, we may expect it to effect a great reduction in the cost of location for ship railways.

RAILROADS.

There were built in the United States, in 1890, according to the best authority, 6,344 miles of new railroads. This was less than an average of the new mileage of the preceding five years, but it was considerably more than was built that year in any other country. It left us with an aggregate of 167,741 miles, nearly one-half of which has been constructed since 1879, and amounts to nearly 44 per cent. of the total railroad mileage of the globe.

Improvements in the operation of existing railroads have during the past year fully kept pace with construction. The extension of the operating and safety appliances so fully and ably treated of by my predecessor, President W. P. Shinn, has continued; and the application of signals, of steam heating and gas lighting for passenger cars, and power brakes and automatic couplers for freight cars has progressed with an accelerating ratio.

AUTOMATIC BRAKES AND COUPLERS.

With regard to the latter, a recent issue of *Engineering News* states that companies controlling nearly 87,000 miles of railway (over one-half the total mileage of the country) and 697,000 freight cars have adopted the Westinghouse automatic brake, and are applying it either to all new cars or to certain classes of new cars. Over 150,000 cars, or 13 per cent. of the whole, are now so equipped. Also that on January 1, 1891, the total number of cars equipped with the master car builders' automatic couplers was over 102,000, or nearly 9 per cent. of the freight rolling stock in the United States.

There were last year, as stated by President Shinn, 101,576 freight cars with Westinghouse air brakes and 56,050 freight cars with master car builders' couplers.

IMPROVEMENTS IN LOCOMOTIVES AND CARS.

You were told last year in the annual address what had been accomplished up to that time in the way of locomotives, and you have been told at this convention, by Mr. W. B. Parsons, of the latest novelty in this direction. The problem is, as you know, how to get increased tractive power without injuriously increasing the weight of the driving wheels. The locomotive practically started with the Rocket, with one pair of wheels, and a weight of 4¼ tons, then, little by little, additional driving wheels were coupled on, with many failures to get them to pull together, until we reached some two or three years ago the Decapod type, with ten driving wheels coupled together, and a weight of 80 tons.

Now the proposal is made by Mr. Shay to work an indefinite number of driving wheels by providing the locomotive with a line of shafting gearing into the wheels, all of them being drivers. The heaviest locomotive thus far built upon this type is of 80 tons weight. A similar increase has within the last decade taken place in the carrying capacity of freight cars. Ten years ago the 10 ton box car was the standard, and it weighed 9 tons, or nearly as much as the useful load. Now the standard may be said to be the 20 ton car, weighing 12 tons, or six-tenths of the load, while cars of 25 or 30 tons capacity are not uncommon, the latter weighing 13 to 15 tons. It may be questioned, however, whether we are not in danger of going too far in this direction, and losing by the increased wear of rails what we are saving in the hauling expenses. We used to think that weights on driving wheels should be limited to 12,000 pounds, and on freight car wheels to 8,000 pounds. Experiment showed some years ago that with these weights we were getting pressures of 50,000 to 60,000 pounds to the square inch, and now that we are imposing weight on locomotive drivers of 16,000 and 18,000 pounds, and on 30 ton freight car wheels of 11,250 pounds, we may be going too far, and placing crushing or rapidly grinding pressures upon our rails.

It is believed that improvements in terminal facilities have not quite kept pace with other economies in railroad operation and transportation. Switching yards might be better arranged than they are, and cranes might more frequently be used to load and unload goods. Especially is there need for the invention and introduction of some mechanical methods of handling and conveying freight from the receiving doors of the houses to the cars in which they are to be loaded, in order to reduce the large gangs of men now engaged in trucking long distances, at our principal freight stations. As the problem involves both conveying and sorting the freight, it is perhaps insoluble, but it promises sufficient economy and profit to warrant some inventive engineer in considering it carefully.

PIKE'S PEAK AND OTHER MOUNTAIN RAILWAYS.

You may, perhaps, be interested in having your attention called to one or two large foreign railways, and to some novelties in proposed constructions, and first I may say a few words concerning the Pike's Peak Railway, which is just about being opened, and which is the first in this country constructed upon the "Abt" system. This line is 8¾ miles long, and extends from an altitude of 6,600 feet above sea level, at Manitou, Colorado, to one of 14,200 feet at the summit. The system, as most of you know, chiefly consists in applying the power of the locomotive through double cog-wheels, meshing in a rack laid in the center of the track.

This rack is built up of two parallel bars, in which the openings are staggered, so that there are always two teeth of the cog-wheel in full gear, and other teeth are also in contact with the gear, thus greatly adding to the safety and to the ease of motion. The maximum gradient at Pike's Peak is 25 feet per hundred, which cannot be called steep, in view of recent European mountain railways. Thus the "Mount Pilatus" line in Switzerland, built in 1889, on the "Abt" system, and 2·77 miles long, has a maximum gradient of 48 per cent., and the line up Mount San Salvatore, near Lugano (1·02 miles long), which is worked by a wire cable, has a maximum of 60 per cent., or nearly 37 deg. from the horizontal.

These mountain lines seem to have proved very remunerative in Europe, and quite a number of them are in operation or in construction. Even on the Alpine mountain the "Jungfrau," which until recent years was considered as inaccessible, it is proposed to build a railway with maximum gradients of 98 per cent., or nearly 44½ deg. inclination. This is to be worked as a cable railway, and to be wholly in tunnel, the cars being arranged so as to form a piston, by close fit in the tunnel, to insure safety in case of the breaking of the cable, by compressing the air, as was formerly done in this country in certain makes of passenger elevators.

THE TRANSANDINE RAILWAY.

A mixed system is intended upon the 65 miles near the summit of the Transandine Railway now approaching completion in South America, between Buenos Ayres and Valparaiso. This mountain section is to be worked partly by adhesion on gradients of 2½ per cent., or 132 feet to the mile, and partly (the locomotive being geared so that they enter upon the track without stopping) by the use of toothed wheels, upon the "Abt" system, over gradients the maximum of which

is 8 per cent., or 422·4 feet per mile. The whole line from Buenos Ayres to Valparaiso is 850 miles long, of which 701 miles were completed and opened at the last accounts, and the remaining 149 miles were under construction through the mountain section, involving very heavy work and a large number of tunnels, many of them in the region of perpetual snow, 10,000 feet above the sea. It is being constructed by English engineers and contractors.

THE HYDRAULIC SLIDING RAILWAY.

Among railroad novelties may be mentioned the Hydraulic Sliding Railway, a section of which has just been opened near the Crystal Palace, in London. This is the same "chemin de fer glissant" which was exhibited at the Paris Exposition of 1889, and there attracted much attention.

The principal feature of this decidedly novel invention is that it dispenses entirely with wheels, and substitutes therefor a series of iron shoes which carry the railway car, and rest upon a broad flat rail. The shoes are perforated with a very narrow annular orifice, or slit, through which water is forced at high pressure, so as actually to raise the shoes off the rail, and to float the cars upon a very thin water bed between the shoe and the rail. This, as may be imagined, reduces the resistance to forward motion to a minimum, experiment having shown that this hydraulic friction on the sliding railway is, on a level, less than one-fifth of the usual rolling friction of the wheels on an ordinary railway. As the whole train is thus afloat on this film of water, it may be asked how impulse is communicated to it from the motive power. This is ingeniously done by a series of water jets issuing from fixed nozzles along the roadway, which are opened and closed automatically by the train itself, and which impinge upon suitable pallets attached under the cars. As may be realized, the consumption of water is great, and other methods of propulsion have been proposed, but thus far without any practical results. This novel system has been mentioned more as a matter of curiosity than as one from which satisfactory results in transportation are to be expected, although the promoters of the scheme claim that speeds of 70 to 125 miles an hour have been obtained, and that no less than 94 per cent. of the fuel required to drive a train can be saved, giving actual experimental figures to prove it. Such data were evidently obtained upon a level line, and we all know that the resistance on a level is but a very small part of that to be encountered upon a railway. The wheel friction, for instance, is 4½ to 5 pounds per ton, while that from gravity on a grade of 52·8 feet per mile is 20 pounds per ton; and there are in addition the resistance from curves and from the atmosphere—the latter at high velocities sometimes forming an important fraction of the whole. For journal bearings, however, for cranes, and possibly for drawbridges, this idea of supporting a weight upon a thin film of water, issuing at a great pressure, may be worth experimenting with.

THE SIBERIAN RAILWAY.

One of the great railways of the world, which is eventually to be over 5,000 miles long, is now under construction by the Russian Government across Eastern and Western Siberia. For the present it is to consist of two isolated sections of railway connecting the navigable waters of rivers in the interior. Beginning at the Pacific end, at Vladivostok on the Japan Sea, the first section is to extend 261 miles to the navigable waters of the Amour; there to connect with 1,590 miles of steamboat navigation. Thence begins another railroad section of 1,895 miles more, which again connects with 1,870 miles of steamboat navigation and thereby with existing railways extending some 1,600 miles further to St. Petersburg. Altogether there are 2,156 miles of railroad to be built now, at an estimated cost of $103,000,000; and the work is expected to be completed in six years. Russia has now about 20,000 miles of railway for some 92,000,000 inhabitants. If it is about to enter upon increased activity in railroad construction, there may be an opportunity for the employment of the rapid and cheap American methods and tools in this as well as in other portions of the world.

THE RAILWAYS OF THE WORLD.

It may be interesting in this connection to inquire as to the relative railroad status of various continents, and having lately had occasion, for another address, to compile and estimate the number of miles of railway in the world on the 1st of January, 1891, the result is herewith graphically exhibited by a diagram. On this

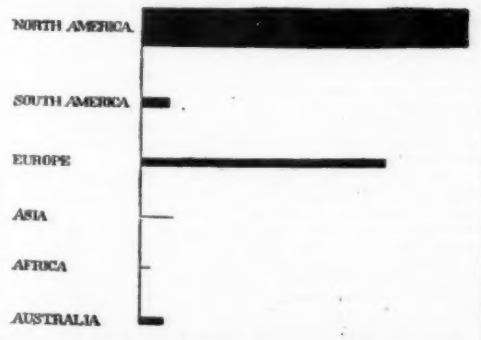


diagram the length of the lines represents the aggregate number of miles on each continent, and the thickness represents the ratio of the number of miles of railroad for each 10,000 inhabitants. The actual figures are as follows:

North America is estimated to possess 187,425 miles, or 21·54 miles per 10,000 inhabitants. South America to have 16,000 miles, or 5 miles per 10,000 inhabitants; while Europe has 141,000 miles, being at the rate of 4·06 per 10,000. Asia having 20,000 miles, or only a ratio of ¼ mile per 10,000. Africa, with 6,000 miles of railroad, averaging $\frac{3}{10}$ of a mile per 10,000 inhabitants, and Australia, ranking nearly with Europe and South America, with 13,000 miles of railroad, and a ratio of 3·42 miles per 10,000 inhabitants. Asia, therefore, and more particularly China, seems to present a field for railroad missionary work, for it cannot fail eventually to ascertain how great a national economy will follow upon the substitution of railroad for other methods of land transportation.

There was occasion, in connection with the schedule of the world's railways already referred to, to estimate this national economy for the United States, and it was found that if we assume that there was a real necessity for the whole volume of the exchange of commodities and movements of passengers (which volume, of course, could not exist at the higher charges), the business done by our railroads in 1889, at the rates of freight and passengers which existed before the railway era, would have cost the nation not less than $12,239,899,980, while the charges actually collected were $993,856,856, thus leaving a difference, or national saving on that basis, of $11,247,043,124, or more than the entire capital invested in our railroads, which, as represented by their stocks and liabilities, amounted to $9,931,453,146.

The average cost of railroads in the United States stands at about $60,000 per mile, while in Europe they are capitalized at about $120,000 per mile, the difference being largely the result of the cheaper methods and designs which original scarcity of capital and labor have led our engineers to develop. The Americans are now the great railroad builders of the world, they execute such undertakings with less expenditures, as measured either in money or in day's work, than other nations, and it seems not impossible that firms of American engineers and contractors shall find it profitable to employ these methods in other countries, let the capital, the labor, or the materials come from whence they may.

(To be continued.)

THE ELECTROLYTIC PREPARATION OF CHLORATE OF POTASSIUM.

FOR the past ten months the manufacture of chlorate of potassium by the Gall-Montlaur electrolytic process has been successfully carried out at Vallorbes. The daily output now amounts to one ton of refined chlorate. According to *La Lumiere Electrique*, M. Lunge states that one H. P. a day=one kilogramme of potassic chlorate, hence a daily production of one ton requires 1,000 H. P. The process is based on the transformation of a 25 per cent. solution of chloride of potassium (KCl) at a temperature of from 45° C. to 55° C., into chlorate ($KClO_3$) by the action of the chlorine and potassium liberated by electrolysis. The chlorate is precipitated, collected, washed, dried and purified. One of the preliminary difficulties was the selection of suitable connections for the electrodes, since the slightest trace of certain metallic oxides in the solution arrests the process. The vats are 270 in number (half being in use at one time), rectangular in shape, and arranged so as to permit of the rapid handling of the volume of liquid, amounting to 11,000 gallons per diem. A porous diaphragm separates the cathodes from the anodes, the former being of iron and the latter of platinum (four mils. thick). The solution is kept at the proper temperature by the current itself. Power is obtained from the falls of the Orbe, which can supply 2,500 H. P. At present there are installed at the generating station ten 150 H. P. Riether turbines, and 105-kilowatt Thury dynamos. The generating plant is at the foot of a mountain, the works themselves being 330 feet and the reservoir 230 feet above the station. This arrangement has the twofold advantage of obtaining a great head of water and of removing the machinery out of reach of the fumes given off in the process. The hydrogen liberated at the cathode amounts to 3,530 cubic feet per ton of chlorate turned out, and as this large volume of gas escapes into the air, carrying with it a certain amount of chloride of potassium, the vicinity of the works is covered with a thick, white saline deposit of a highly erosive character. With ample water power available, the electrolytic process can undersell the chemical process, although at present only 400 tons per annum is being produced by it, as against 8,000 tons by the older method. Some 5,000 tons of this total is produced by the works of the Chemical Union. The electrolytic process is cleaner, simpler, quicker, leaves no residue, and needs no coal for mere heating purposes.

POCKET ELECTROMETERS.

By C. V. BOYS, F.R.S.

As quartz fibers increase the delicacy and diminish the disturbing influences affecting instruments, much smaller controlling forces can be employed than when

FIG. 1.—Cylindrical "needle," with four insulated sections containing a dry pile.

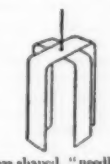


FIG. 2.—Cross shaped "needle," consisting of a strip of platinum and a strip of zinc, charged by its own contact difference.

FIG. 3.—Disc shaped "needle," with alternate quadrants of zinc and platinum, one of the enclosing quadrants being removed.

silk is used for suspensions. The author had, he said, pointed out some time ago the great advantages arising from making galvanometers small. Applying similar reasoning to electrometers, he remarked that making an instrument one-tenth the size of an existing one reduced the moment of inertia of the needle to $\frac{1}{1000}$, while the deflecting couple for given potentials would only be $\frac{1}{10}$ of its former value. The small instrument would, for the same periodic time, be 10,000 times more sensitive than the large one, provided the disturbing influences could be reduced in the same proportion. This, however, was not ordinarily possible, for any method of making contact with the needle such as by a fine wire dipping into acid or mercury prevented very small controlling forces being used. Still, by suitable devices, a large proportion of the full advantage could be obtained. A freely suspended needle without liquid contacts was essential to success. The first instrument described was one in which the needle was cylindrical (Fig. 1), contiguous quarters being insulated and connected to the opposite ends of a minute dry pile placed within the needle; opposite quarters were then at the same potential, and at a different potential to the other pair of quarter cylinders. This was suspended within a glass tube silvered on the inside and divided into four parts by fine longitudinal lines. In such an instrument the needle and quadrants are reciprocal, and the deflection depends on the product of the difference of potential between the quadrants and that between the parts of the needle. Owing to the dry pile not being constant, the instrument was found unreliable, but when working at its best, a Grove cell would give 30 or 40 millimeters deflection. The next step was to make a cross shaped needle of zinc and platinum (Fig. 2), and rely on contact electricity to keep the parts of the needle at different potentials. This bold experiment proved remarkably successful, for the instrument was very sensitive. A disk-shaped needle, with quadrants alternately zinc and platinum, was then employed, and by this a small fraction of a volt could be measured. The weight of the disk was only $\frac{1}{10}$ of a gramme, and the instrument could be turned upside down or carried about in the pocket with impunity. Another small instrument with the quadrants of zinc and copper (Fig. 3) was exhibited, and by rotating them through an angle of 90 deg., so as to bring them in a different position relative to the parts of the needle, a deflection of several degrees of arc was produced. Mr. Boys made several suggestions relating to ballistic electrometers and electrostatic Siemens dynamometers, and pointed out the possibility of instruments such as he had exhibited being of use in elucidating the obscure points in connection with so-called "contact electricity."—*The Electrician.*

THE EDISON PATENT DECISION.

IN July, at New York, Judge Wallace filed his opinion in the United States Circuit Court in the patent suit of the Edison Electric Light Company against the United States Electric Lighting Company, owned by the Westinghouse Company. The argument was made before him a month ago on the Edison patent No. 223,898 for an incandescent electric lamp, and took eight days. The printed testimony fills seven volumes, or about 6,000 pages. The taking of the testimony had kept the lawyers on both sides busy almost continuously for two years and the printed briefs of the arguments of counsel on both sides are eight in number, covering about 1,000 printed pages. Judge Wallace's opinion fills 23 pages of typewritten legal cap, and sweepingly sustains the patent, a decree of injunction and accounting being ordered.

Edison's invention was made in 1879, and his patent was granted in 1880. The suit was begun in 1885, the subject in controversy being two claims of the letters patent No. 223,898, "for an improvement in electric lamps." These two claims were as follows:

1. An electric lamp for giving light by incandescence, consisting of a filament of carbon of high resistance made as described, and secured to metallic wires, as set forth.

2. The combination of carbon filaments with a receiver made entirely of glass and conductors passing through the glass, and from which receiver the air is exhausted for the purposes set forth.

Judge Wallace decides that the defendant does not infringe the first claim, because the leading wires in its lamps are not secured to the filament according to the method of the patent, but, on the second claim, judgment is given for the plaintiff, that being in reality the essential feature of the invention claimed by the Edison Company.

The following is the most important part of the decision:

The second claim is broad enough in its phraseology to secure the real invention described in the specification, and can be read consistently with its language so as to import into it every essential limitation.

It was a remarkable discovery that an attenuated thread of carbon would possess all the long sought qualities of a practical burner when maintained in a perfect vacuum. The extreme fragility of such a structure was calculated to discourage experimentation with it, and it does not detract in the least from the originality of the conception that previous patents had suggested that thin plates or pencils or small bridges could be used. The futility of hoping to maintain a burner in vacuo with any permanency had discouraged prior inventors, and Mr. Edison is entitled to the credit of obviating the mechanical difficulties which disheartened them, but what he did in this respect was a matter of only secondary merit, and was no longer new in the art, because he had already disclosed it in his French and English patents.

What he actually accomplished was to unite the characteristics of high resistance, small radiating surface and durability in a carbon conductor by making it in a form for extreme tenuity, out of any such materials as are mentioned in the specification, carbonizing it, and arranging it as he had previously arranged his platinum burner in an exhausted bulb made wholly of glass and sealed at all points, including those where the leading wires entered, by the fusion of the glass. He was the first to make a carbon of materials and by a process which was especially designed to impart high specific resistance to it, the first to make a carbon in the special form for the special purpose of imparting to it high total resistance, and the first to combine such a burner with the necessary adjuncts of lamp construction to prevent its disintegration and give it sufficiently long life. By doing these things he made a lamp which was practically operative and successful, the embryo of the best lamps now in commercial use, and but for which the subdivision of the electric light by incandescence would still be nothing but the ignis fatuus which it was proclaimed to be in 1879 by some of the learned experts who are now witnesses to belittle his achievement and show that it did not rise to the dignity of an invention.

The coiled form of the burner is only an alternative feature, and is not a constituent of the second claim. It is the subject of the third claim. Nor is the bent form or any form other than the filamentary. It may be that in the haste which has always seemed to characterize Mr. Edison's efforts to patent every improvement, real or imaginary, which he has made or hoped to make, he had not stopped to reflect when he framed his application for the patent that the filamentary burner would do its work just as well uncoiled as coiled, provided the same length and cross section were used. It is true that it is said in the general statement of the nature of the invention that the burner is so coiled or arranged as to offer high resistance and present a small radiating surface; but this description is satisfied by any arrangement, whether by coiling a considerable length in a small globe or using the same length of uncoiled in a larger globe, by which sufficient total resistance is obtained from a filament of small diameter. It certainly would not involve invention to omit the coiling and elongate the globe; hence, it is manifest that the invention described is the same thing essentially, whether the coiled form is used or not.

The language is satisfied if the burner is filamentary and so arranged as to offer great resistance and slight radiation, without importing into it anything which is not of the essence of the invention. No precise limitation upon the maximum diameter of the filament can be defined from the specification or is required as an element of the claim. The specification mentions by way of illustration the threads of linen or cotton which become more attenuated after carbonization, and the carbon wire which after carbonization would be from $\frac{1}{1000}$ to $\frac{1}{500}$ of an inch in diameter, while the smallest rods of carbon previously known were about a millimeter in diameter, thus having a cross section fifty times as great as the carbon wire.

It is to be implied from the suggestions in the specification that it is to have sufficiently high total resistance for efficient use when the lamps are arranged in multiple arc, and to be used with leading wires of fine platinum. The claim is not limited to a carbon filament made of non-fibrous materia[1]. The conductors of the claim are the platinum wires mentioned in the specification. The receiver is the vacuum described in the specification. The peculiar method of securing the conductors to the filament, made a constituent of the first claim, is not imported into the second claim. A more exact interpretation of the meaning of the claim than has thus been indicated is not necessary in the present case, because each of the three lamps representing the kinds used by the defendant embodies the invention of the claim as thus interpreted.

It is of little import what Mr. Edison, or his patent solicitor, may have thought about the meaning of the claim during the pendency of the application for a subsequent patent, or that Mr. Edison may have supposed a resistance as high as 100 ohms in the burner would be required for use with the means of distribution which he expected to employ with his system of lighting. There are many adjudicated cases in which it appears that the inventor built better than he knew; where a patent has been sustained for an invention the full significance of which was not appreciated by the inventor when it was made.

The questions which have seemed most meritorious of those argued at the bar have now been considered. Others, to which no reference has been made, have not been overlooked, and may be dismissed without discussion, and with the single remark that nothing which has been presented by the voluminous proofs and the exceedingly able and elaborate arguments of counsel seems to supply any valid reason for refusing to decree for the plaintiff. The usual decree for an injunction and accounting is accordingly ordered.

DE LALANDE'S NEW OXIDE OF COPPER BATTERY.

Mr. F. De Lalande has just made an interesting improvement in the battery invented by him and Mr. Chaperon a few years ago. The reaction of this apparatus is well known. It assists in the dissolution of zinc in caustic potash and a depolarization through oxide of copper, which absorbs the hydrogen in becoming reduced to a metallic state.

In the old models the oxide of copper was generally employed in the form of grains placed simply at the bottom of a metallic vessel forming the receptacle of the element, or else in a small cup occupying the bottom of a glass vessel. The zinc was arranged at the upper part of the vessel, in the form of a horizontal plate or of a rolled band.

In the new models (Figs. 1, 2, and 3), the plates of agglomerated oxide of copper, C, are held vertically, opposite the zinc plates, *z z*, against metallic supports, D D, fixed to the covers, B B, of the elements. The whole is immersed in a solution (about 35 per cent.) of potash contained in a glass jar, A. Among other advantages, this arrangement presents that of giving elements that are compacter and easier to dismount.

The agglomerates of oxide of copper may be prepared by moulding in a hydraulic press a damp mixture of copper scales with 4 or 5 per cent. of clay, and baking the product at a temperature of from 600 to 700 degrees. The scales may likewise be mixed with 6 or 8 per cent. of tar, and be moulded, and submitted to red heat in a reverberatory furnace. There is first produced a reduction of the oxide, whence results the agglomeration of the mass; then, under the influence of the air, the metal oxidizes without alteration of form. The plates thus obtained, although containing no foreign matter, are very strong. Their porosity in both cases is sufficient to allow the whole of the oxide to exert its depolarizing action without the introduction of a notable resistance into the battery.

One of the most interesting peculiarities of the zinc-oxide of copper couple is the increase in depolarizing power consequent upon the work of the element. This rare phenomenon of a battery whose disposable energy continues to increase from the beginning of the discharge before reaching the state of regular operation can be easily explained. The oxide of copper being a poor conductor of electricity, is capable of depolarizing only at the points of contact with the electrode; but, as the copper produced by its reduction conducts very well, the surface interested in the depolarization increases very rapidly and the absorption of the hydrogen becomes more easy and rapid. There is thus produced a sort of *formation* of the electrode. If, then, the agglomerates manufactured as has been described were used just as they are in the batteries, the depolarization would be imperfect at the beginning, the parts in contact with the metallic support being alone capable of acting through their feeble surface. The element would have to be closed upon itself for some minutes in order to be put in condition.

It is much preferable to put the depolarizing electrode immediately in the best condition for operating by metalizing it, so as to render it conductive. The active surface is thus greatly increased, and this suppresses the period of formation. To this effect the agglomerate is covered with a thin layer of zinc by immersion in a mixture of water and of zinc in suspension, and is then dipped in slightly acidulated water. The zinc in dissolving forms a series of local couples with the oxide of copper, whose surface is rapidly reduced to a metallic state. The agglomerates thus treated, having a conductive surface, would give good results in batteries, but if, after washing them, we wish to dry them, the porous copper reduced on the surface rapidly reoxidizes, and the conductivity is lost. In order to obviate this inconvenience, the agglomerates, on coming from the acid bath, are put into an electro-metallurgic bath, and are covered with a thin and continuous layer of copper. On employing a current of short duration and great intensity (2 to 3 amperes per square decimeter of surface of the agglomerate), the deposit will have a porosity such as not to increase the interior resistance of the batteries. It then suffices to wash and dry the metallic plates. The deposited copper does not reoxidize, and the surface remains conductive. These agglomerates, converted into metallic copper by the work of the battery, may be employed again for several times, after being washed, grilled, and metalized. The system of mounting the agglomerates and zincs is the same in the three models. The support, D D, of the agglomerate (Fig. 2) is fixed to the earthenware cover, B, by means of screws and nuts, one of the screws carrying the positive terminal, E. It is formed of a copper coated plate of iron, of rectangular form, hollowed out, and with parts of it bent so as to form a lodgment for the plate. In order to mount the agglomerate, it is placed in the position that it is to occupy (Fig. 4) and is held by two curved springs, L L, of hammered copper, whose lower extremities enter apertures, M M, at the base of the support. The upper extremities of the springs are afterward introduced into slits, N N. This very rapid method of mounting keeps the agglomerates in perfect metallic contact with the support.

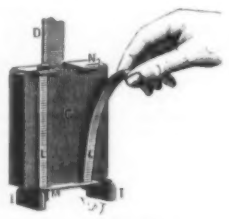


Fig. 4.—MOUNTING OF AGGLOMERATES.

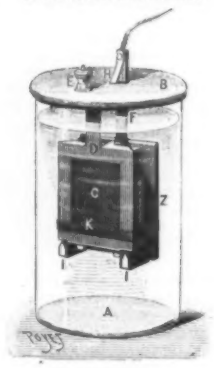


Fig. 1.

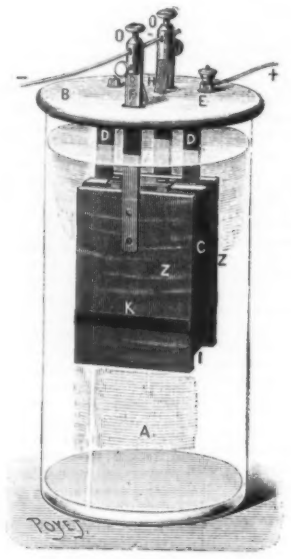


Fig. 2.

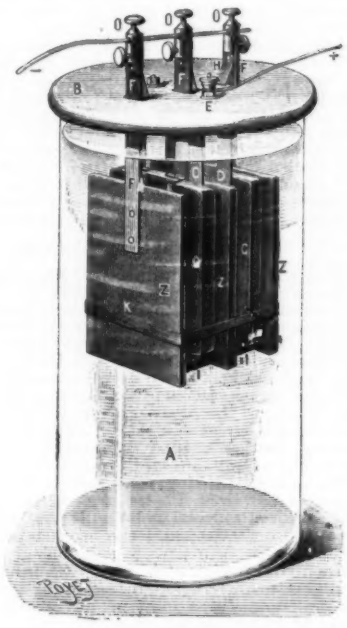


Fig. 3.

DE LALANDE'S NEW OXIDE OF COPPER BATTERY—SMALL, MEDIUM, AND LARGE SIZES.

As for the zincs, they are supported by strips of metal, F F, passing through rectangular apertures in the cover. To the upper part of these supports are fixed steel springs, H H, which are capable of traversing the cover on being compressed, and which, on afterward resuming their natural position, support the weight of the zinc and rest upon the surface of the cover. In the small model, a conducting wire is fixed to the zinc; in the other models, there are placed in each of the zincs metallic binding screws, O O O, connected by the negative conductor.

The zincs, moreover, are supported at a proper distance from the negative electrode by ebonite insulators, I I, fixed upon the supports of the oxide of zinc. The agglomerated plates and the zincs are surrounded by a rubber band, K.

The zincs must be kept entirely immersed on account of the rapidity with which they wear away at the level of the liquid. Their supports are usually made of copper or amalgamated brass. Tinned iron, which is cheaper and more resistant, may also be employed.

The electrodes do not extend to the lower part of the vessels. The zinc potash compound that forms during the operation of the battery separates quite freely, in consequence of its great density, in the form of a layer that occupies the bottom of the vessel. The electrodes, being near the surface, therefore remain the longest time possible in the solution of potash that is to attack them. In the presence of a saturated alkaline solution, or a nearly saturated one of oxide of zinc, the surface of the zinc would become covered during the operation of the battery with a layer of oxide, in consequence of the need of a solvent, and would no longer be able to operate effectively.

The general properties of the oxide of copper battery are well known. Up to the present it is the only primary element with permanent mounting that is capable of a large discharge, and that consumes its elements only in proportion to the work furnished. In the new models, the use of agglomerates with metalized surface permits, from the beginning, of causing a very wide depolarizing surface to act, and this increases the constancy of the elements. The bringing of the surfaces near to each other diminishes the internal resistance. The discharges are, consequently, greater and the constancy more complete for elements of comparable dimensions, in the new as well as in the old models. —*Le Genie Civil.*

TANNING BY THE AID OF ELECTRICITY.*

By Dr. S. Rideal, F.I.C., F.C.S., and A. P. Trotter, B.A., A.M.I.C.E., A.I.E.E.

The slow rate at which a hide is converted into leather in the ordinary process of tanning has induced many inventors to devise methods by which the chemical change might be accelerated without deterioration of the quality of the leather produced, but the want of any definite knowledge as to the precise nature of the interaction which takes place between the gelatin of the raw hide and the various tannins employed in this industry has been a serious obstacle in the development of these methods, and many of the proposals, after having been tried on a small scale, have been abandoned in favor of the old and slow process. It is necessary to refer to some of these proposals in order to understand the position of the industry a few years ago, when the first important steps toward the employment of electrical energy for hastening the tanning process took place.

One of the earliest patents for accelerating the process of tanning by mechanical methods is that of Francis G. Spilsbury, of Walsall, Staffordshire, and is dated 1823. He used oblong frames of wood and stretched the hides on these, placing a frame between, and thus forming a vessel, having stretched hides for its sides. Into this vessel the tanning liquor was run through a pipe from an elevated tank, pressure being regulated by the hydrostatic head. The hides became distended and the liquor oozed out, forming drops like dew. By this process it is said that the hides can be tanned in six weeks, or in some cases in eight or nine days, instead of a year. The process was abandoned, owing to the trouble entailed in closing any holes or tears in the hides and the considerable waste caused by cutting the hides to fit the frames. Another early invention for hastening tanning was that of T. J. Knowles, who employed an air tight vat. The hides were suspended in the liquor from hooks at regular intervals, and were provided with leaden weights to keep them uniformly stretched. The air was exhausted by a pump, and after an interval the liquor also was removed and the air admitted. This process was repeated until the tanning was accomplished.

One of the first applications of mechanical motion was that of W. Brown, of New York, who employed a reel or cylinder, composed of two heads and a number of longitudinal bars with pins on the outer surface on which the hides were fastened. He also threw them loose into the cylinders, which were slowly rotated by means of ratchet gear. In America a rocking bar was used, the hides hanging from it and alternately dipped into the liquor and withdrawn from it. A modification of this consisted of a frame moving up and down, dipping the hides in the vat. These and other mechanical methods were used for the simple purpose of obtaining a continually fresh application of the tanning liquor to the surface of the leather, instead of the ordinary daily handling of the hides. These mechanical processes may be broadly divided into two classes: those in which the hides are allowed to hang or are stretched on frames, and those in which they are rolled or churned loose, in bulk. In the former class the stirring of the liquid is practically as efficient as in the latter, but there is no tendency to remove the soluble or soft gelatin and albumen by kneading and churning, and the hides being always surrounded by the liquor, the tannage proceeds uniformly in every part.

* A paper recently read before the Society of Chemical Industry; from the Journal.

So far, the mechanical processes are designed for an obvious purpose, but when we come to the application of electricity to tanning, we find that the inventors are groping in the dark, using a powerful operator, but with no rational principle or motive. The only *a priori* reasons for applying an electric current to a hide in a tan pit are that some electrolytic action *may* liberate some tanning agent in a nascent state, and that dialysis is accelerated by the passage of a current, and that there is a relation between osmosis and electrolysis.

As early as 1849 a tanner named Crosse proposed to utilize "electricity or galvanism for tanning purposes." The electrodes consisted of sheets of zinc and lead, immersed in an ordinary tan pit in which water and the hides were placed, bark or other tanning material being added from time to time, after the skins had been subjected to this action for some days. Ward, in Lancashire, some years later, passed a current of electricity through the tanning liquor in ordinary tan pits. In 1861 Rebu made several experiments on electrical tannage, employing various metallic salts as well as ordinary liquors in his pits. In 1874 De Mertens, of St. Petersburg, turned his attention to the subject, and has for some years adopted in nearly 600 pits the following plan of electric tanning. A layer of carbon connected with the positive pole of a dynamo is placed at the bottom of each vat and it is then filled with the alternate layers of moist skin and tan, a plate of zinc forming the negative pole at the top of the pit.

In 1876 Lucier Gaulard and Kresser proposed another process, in which they used two parallel plates of carbon, and immersed the hides between them in tanning liquor, passing a continuous current of electricity through from plate to plate. Leather made by this process was exhibited in London in 1883. The process of Landin & Abom has been worked for more than two years in the tan yard of Messrs. Nielson, of Norrkoping, in Sweden. Here the hides are attached to wooden frames and are placed in a pit. Large copper electrodes are provided, and an alternating current is passed.

A simple combination of motion and electrical treatment was patented in France by Worms & Balé in 1887 (this journal, 1888, 44, 587), and consists of a large drum, some 11 ft. in diameter, mounted on a horizontal shaft and filled one-third full of tanning liquor, together with some turpentine, and in this half a ton of hides are placed loose in bulk. The drum is set in motion by steam power, and a current of about 10 amperes is passed through the contents by means of copper electrodes placed on the interior surface of the ends of the drum. Nicholson & Palmer (Eng. pat. 9,776, 1889) have also described a similar process, in which the hides are suspended on the positive electrode within the rotating drum, and the current of electricity is caused to flow mainly through the hides.

Another distinct process is to be found in the Groth system of tanning (this journal, 1888), a description of some of our experiments on which forms the subject of the present communication. In Groth's apparatus there is a combination of motion and electrical treatment, but the motion is of such a nature that the hides, being left stretched and suspended in the liquor, are not churned about or rubbed one on the other, as in Worms & Balé's process.

The two practical forms in which Groth's invention has been worked at the Grange Works, Bermondsey, are first, a round vat containing a revolving frame carrying the hides, and secondly, a rectangular tank in which a similar frame is carried to and fro, running on wheels, and moved by a crank. One of the circular vats placed at our disposal was 7 ft. 3 in. in diameter and 6 ft. 4 in. deep. The cubic contents were thus about 315 cub. ft. or nearly 2,000 gallons. The sectional area in a vertical plane is about 43½ sq. ft., the superficial area in plan is 42 sq. ft. A strong central shaft turns in bearings and is driven by bevel gear, the arrangement being precisely like a brewer's mash tun. Wooden arms are attached to the shaft and carry cross pieces. These are provided with a number of brass hooks, by means of which the hides are hung vertically, about an inch apart, all the metal work in contact with the liquor being brass or copper.

Electrodes are placed against the sides of the vat. These consist of strips of copper arranged gridiron fashion. Four strips 4 ft. 3 in. long by 2 in. wide are placed 8 in. apart, and are connected at the top and at the bottom by strips of similar width. The whole surface exposed is therefore about 4 sq. ft. Experiments were also carried out in a rectangular vat in which the hides were moved backward and forward longitudinally.

The tanning liquors were made of the usual materials, and during the tannage were strengthened from time to time in the usual way, and the hides were prepared for tanning by liming, unhairing, fleshing, and coloring, as practiced by most tanners.

The current was varied in different experiments, according to the nature of the hides and strength of liquor. This is important in order to obtain satisfactory results. Previously to our investigation a series of experiments, in which the current varied from 1 to 30 amperes, was employed; best results were obtained with the weak currents, and the considerable loss due to electrolytic action when a greater current was employed was thereby avoided. With a current from 1½ to 4 amperes, the density is from 0·375 to 1 ampere per sq. ft. of electrode, and from 0·0345 ampere per sq. ft. of transverse sectional area of the contents of the vat to 0·092 ampere per sq. ft.

For currents from 1·3 up to 2·3 amperes, the total resistance of the liquor at 9° C., sp. gr. 1·01, expressed, for convenience, in ohms, was 8·7. On another occasion, at 7° C., sp. gr. 1·019, the resistance was 7·7 ohms, with 2·3 amperes. In each case the resistance was measured by observing the current and the volts between the electrodes. The quotient gives the sum of the ohmic resistance and of the polarization. Exploration of the vat by means of a movable electrode showed that the flow of current was very uniform.

In our earlier experiments the current and voltage were observed, the vat being full of tanning liquor up to a certain mark. The hides were then put in, displacing a certain quantity of liquor. This was removed until it stood at the same mark as before, and the resistance was again determined. The results obtained in this way, however, did not give us any very definite information as to the variation in the resistance of the hides during their conversion into leather, but were sufficient to show that the hides when just immersed did not offer any material additional resistance to the electric current. Arrhenius (B. A. Electrolysis Report, 1887, 345) has previously pointed out that the resistance of solidified gelatin is not different from that of gelatin solution.

A more careful and accurate series of observations were subsequently made on the electrolytic resistance of the tanning solution, from which the following curves were obtained.

The temperature coefficient was, as might be expected, negative. The resistance decreased 0·9 ohm for a rise of 1° C. or 1·32 per cent. at 16° C., falling from 75 ohms per cubic inch at 8·6° C. to 59 ohms per cubic inch at 26° C. The liquor was a strong solution containing 4·25 per cent. of tannin, obtained from mimosa bark and gambier, such as was employed during the later stages of the tannage. The same sample was tested for the purpose of ascertaining the true ohmic resistance and the fall of volts due to polarization with different current densities on the electrodes. The resistance of the given sample of the liquor at 8·5° C. was 82 ohms per cubic inch—11 d where d is the density in amperes per sq. ft. of electrode. This is shown by the straight falling line in Fig. 1—

$$v = 82 - 11\,d$$

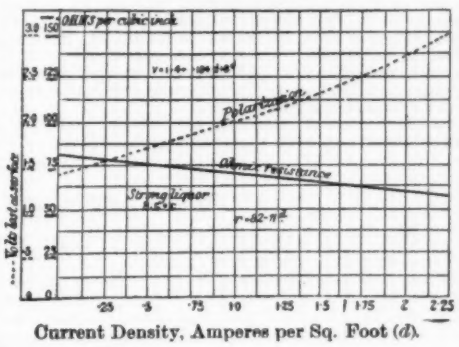
The voltage lost at the surface of the electrode is not so simple a quantity. It tends to a minimum of 1·4 volts for a minimum current, and the two following empirical formulæ closely approximate to the observed curve—

$$\text{Volts} = 1{\cdot}4 + 45\,d^{1{\cdot}2}$$
$$\text{or} = 1{\cdot}4 + 0{\cdot}194\,d + 8\,d^{2}$$

where d is the density of current in amperes per square foot. This is shown by the rising curve on Fig. 1.

Fig. 1.

POLARISATION EFFECT.



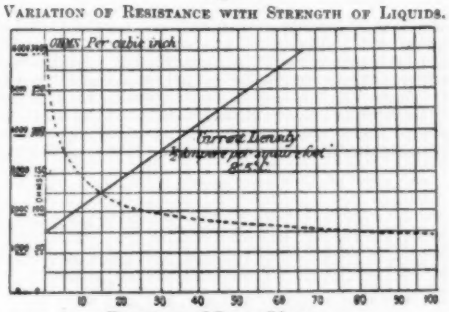
Current Density, Amperes per Sq. Foot (d).

A third series of tests were made to determine the change of resistance produced by diluting the liquor with water.

The curve of the results of the observations, shown in Fig. 2 by the dotted curve, which evidently bears a strong resemblance to a rectangular hyperbola, and on analyzing it by plotting the relation of the product of the resistance into the strength, with the strength (taking the normal strong liquor of 4·25 per cent. of tannin as 100) the result is a straight line, shown on the diagram, the slope of which is 63, and it cuts the

Fig. 2.

VARIATION OF RESISTANCE WITH STRENGTH OF LIQUIDS.



Percentage of Strong Liquor.

axis of the abscissæ at 1,200. The curve is, therefore, a rectangular hyperbola, that is to say, the resistance is inversely proportional to the strength of the liquor plus the resistance to which the curve is asymptotic, that is, the resistance of the saturated solution per cubic inch would be 63 ohms per cubic inch. The formula is therefore $r = \frac{120}{s} + 63$ where s is the strength of the liquor per cent., 100 being the normal solution referred to.

With the view of ascertaining whether the mechanical stirring of the liquor had any oxidizing or other effect upon the liquor, a vat was filled, and the frame was kept rotating as in ordinary work, but without any hides, for 24 hours. Analyses of the liquor before and after this treatment gave identical results as far as the practical point of the percentage of tannin is concerned, thus showing that the stirring has no effect other than that of continually bringing fresh liquor to act on the surface of the hides. A similar experiment was made to determine the effect of passing an electric current of ordinary working strength for 9 hours through the vat simultaneously with the motion of the frame. At the end of the experiment the liquor contained the same percentage of tannin. This result was to be expected, as the electrical power is remarkably small and the current density in the liquor is far below that of any ordinary electrolytic operation. Taking the mean volts and amperes of the second test already mentioned, and deducting 1·6 volts for polarization, we have 36·8 watts expended in the liquor. It is obvious that this very small power, about $\frac{1}{20}$ of a horse power, can have but little effect on 2,000 gallons of liquor. The electrolytic effect is negligible when such weak currents are employed, since a current of two amperes will only liberate from water 0·075 grm. of hydrogen and 0·6 grm. of oxygen per hour, or during the whole process considerably less than 10 grms. of hydrogen would be evolved.

In our earlier chemical experiments with this process, our efforts were directed toward establishing the rate at which the tannin is taken up by the hides with and without the use of motion and an electric current. It was also of interest to determine whether the rate of tannage in the circular vats, in which the hides were suspended on a rotating frame, was similar to that obtained when a square vat was employed, and the hides suspended on a frame to which a reciprocating motion was imparted as already described.

In these first experiments the rate of tannage was determined by noting the loss of tannin from the liquor after given intervals of time, and from the data so obtained calculating the average rate of loss per hour from the liquor.

The following table summarizes the results obtained in three complete tannages in which the process was discontinued at night, so that the electrical current and motion was only applied to the experimental vat from six to eight hours per diem:

TABLE I.

Experiment.	Loss of Tannin per Hour per 10,000 Parts of Liquor.	
	Day.—With Motion and Electricity.	Night.—Without Motion and Electricity.
Circular vat 1, 1,600 gallons...	·62	·344
Circular vat 2, 2,400 gallons...	·612	·340
Reciprocating vat.....	·333	·338

The experiment in the circular vat 1 extended over a period of 26 days, during which time the machine was in motion for 167 hours, and a current of electricity applied for 98 hours to the 20 butts tanned in this experiment.

The second experiment in vat 2 lasted 33 days, during 209 hours of which the hides, 30 in number, were in motion and a current of electricity passed for 115 hours.

In the reciprocating vat 40 bellies and 20 shoulders were in the liquor for 27 days, the machine was in motion for 181 hours, and a current of electricity simultaneously applied for 82 hours. In each experiment the hides were completely tanned when they were taken out of the vat, and when finished were reported to be leather of excellent quality.

Daily temperature readings of the liquor were taken, but on no occasion was the temperature markedly different from that of the surrounding air, 15° C. being the highest reading recorded, and on some days the liquor being as low as 5° C.

The following table gives the actual experimental numbers obtained in the second of the above tannages, from which the average numbers given in Table I. for this experiment were obtained.

TABLE II.

CIRCULAR VAT 2.

Strength of Liquor in parts per 10,000.		No. of Hours.	Total Decrease per 10,000.	Decrease per Hour per 10,000.
Machine Started.	Machine Stopped.			
A. With Electricity and Motion. Day.				
92·8	89·4	5	3·4	·68
93·8	90·0	7	3·8	·54
84·6	81·2	5·5	3·4	·618
139·2	134·15	8	5·05	·63
127·8	123·05	8	4·75	·593
Average ·612 parts per hour per 10,000.				
B. Night, at Rest.				
89·4	84·4	14	5·	·357
99·4	93·8	15	5·6	·373
99·0	84·6	14	5·4	·385
105·6	100·2	14	4·4	·33
133·8	129·6	14	4·2	·3
282·2	268·3	45	13·98	·304
Average ·340 parts per hour per 10,000.				

The concordant nature of the above figures, as well as similar ones obtained in the other two experiments mentioned in Table I., at first led us to imagine that the hastening due to the combined action of motion and the electric current was expressed by these numbers. Further experiments to be referred to later, however, proved to us that the rate of absorption at night, after the action of the electric current had been continued for some hours during the day, was much greater than that observed when the hides had not previously been subjected to this influence; in other words, the increased rate of absorption continued after the machine was stopped and the current was switched off.

This effect may in all probability be attributed to the fact that as the hides pass through the liquor, the pores of the skins become distended, and thus facilitate the passage of the liquor through the hides, which remain in this distended state for some time after they are brought to rest and the electric current cut off. When the machine is at work the hastening is further increased by the motion of the hides in the liquor augmenting the frequency of contact of the tannin molecules with uncombined gelatine, and when the current is passing a further hastening is no doubt due

to the increased motion of the tannin molecules through the liquor which such current imparts to them and its disposition on the suspended hide. An endeavor was also made to trace the change taking place in the hides during the absorption of the tannin, and from the series of numbers obtained it was noticed that the percentage of water present in the well drained hide gradually diminished as the tannage became more complete; the fleshed hide containing approximately 77 per cent. of water and the leather as taken out from the vat from 45—55 per cent., according to the part of the skin examined. A gradual increase in the specific gravity of the dried skin was noticed, 1·062 being the lowest and 1·119 the highest specific gravity obtained. Samples of the leather obtained in these three experiments were subsequently tested by the Kjeldahl process and nitrogen contents ranging from 7·35 to 6·99 were obtained. Very little is apparently known as to the nitrogen contents of finished leathers, and although Bottinger (Ann. 244, 229) has shown that the compound of gelatin with oak bark tannin contains 9·4 per cent. nitrogen, and oak bark tanned leather from 9·03—9·24 per cent., he has pointed out that both of these bodies are decomposed on heating with water, yielding a soluble compound of greater nitrogen content and an insoluble body containing only 7·79 per cent. nitrogen in the former case and 6·17 per cent. in the latter.

It is obvious, if the nitrogen content of a leather can be regarded as an indication of the completeness of the change, that simultaneous determinations of the actual quantity of tannin taken out of solution by an unknown weight of hide substance and their average nitrogen content would give data which would be of value to the tanner, and enable him to predict the weight of his finished leather, and at the same time tell him the cost of the tanning material consumed in the work. Considerable difficulty was at first experienced in obtaining samples of the hide from time to time during the tannage that would represent the average composition of the leather. By taking the precaution, however, of taking the samples from a thick hide along the median line of the back from day to day, the error due to the varying thickness of different hides was reduced to a minimum, and the samples taken were then divided into two portions, one of which was dried at 100°, rasped, and the fillings analyzed, while a second portion was frozen, reduced to fine shavings by means of a microtome, dried, and analyzed, and thus gave a check on the former value. As these are probably the first experiments in which a thick sole leather has been produced in a time sufficiently short as to render it possible to trace the gradual diminution in the percentage of nitrogen in the hide with its absorption of tannin from the ooze, we give a table showing the results obtained in a recent experiment.

Thirty specially selected green hides were marked and weighed, limed in the usual way for six days, unhaired and fleshed, but not scudded, washed and colored in a weak liquor for two days. Their total weight was 2,322 lb., of which the horns, etc., weighed 104 lb., giving a net weight of 2,218 lb. used. The wet fleshed hides when introduced into the vat weighed 1,673 lb., and after the tannage was completed on the 23d day, the wet leather taken out weighed 2,040 lb. The leather has since been finished, and the weight in the dry and finished state was 986 lb. The hair sold weighed 714 lb., and the flesh 569 lb. The following table gives the composition of the leather at different stages of the tannage and the amount of tannin disappearing from the solution.

Table IV.

Date.	N. Per Cent.	Weight of Tannin absorbed in lbs.
Fleshed hides: February 26th	16·5	..
February 28th	14·43	105·3
March 2nd	12·44	258·4
March 4th	10·56	409·3
March 9th	8·95	656·4
March 12th	..	760·0
March 20th	7·50	775·2

It will be noticed that the absorption after 12th March was very slow, and that the total gain in weight estimated from the tannin absorbed during the following eight days only amounted to 15 lb., or about ½ lb. per hide. This slight increase in the weight, unless it markedly affects the quality of the leather, cannot possibly compensate for the extra time and power spent after the 14th day. In this experiment the 775 lb. of tannin consumed were obtained from mimosa bark and gambier, and for estimating the cost we may assume that 625 lb. were obtained from the bark and 150 lb. from the latter. A 35 per cent. bark at £16 10s. per ton would furnish 625 lb. of tannin for £12 9s., and a 50 per cent. gambier at £34 per ton would furnish 150 lb. for £4·55, making a total cost for the tannin materials consumed in tanning the 30 hides, £17·45. Other materials would, of course, work out to a different cost, and if valonia or oak bark had been employed, the cost of tannage would be considerably less.

It will be seen from the above figures that a very large amount of tannin was absorbed during the experiment which was not present in the finished leather obtained. We believe that this result is due to the large portion of the tannin consumed being deposited on the surface of the semi-permeable membrane, and subsequently being removed when the leather is washed and during the finishing process. The difference between the amount found in the finished leather and the amount lost by the liquor during the tannage can, of course, be utilized for further work. Ostwald (Zeits. Phys. Chem. 6, 71) and Tammann (Zeits. Phys. Chem. 6, 237) have recently drawn attention to the deposit of copper in this way from a copper solution on the surface of a semi-permeable membrane of copper ferrocyanide, and it would seem probable that after the gelatin tannin compound is formed the deposition of tannin continues, but on the surface only of the leather. If the experiment had been stopped earlier, the quantity of tannin absorbed would have been less and the amount removed from the surface in the finishing process also less.

Bottinger's experiments already alluded to point to a direct condensation of the gelatin and tannin taking place in the conversion of hide into leather, but so far as we are aware, there have hitherto been no direct experiments that this absorption took place gradually, and that there was a definite relation between the tannin lost by the liquid and the nitrogen content of the hide.

From analyses of the fleshed hide and finished leather the decrease in the nitrogen value and increase in the oxygen per cent. has been repeatedly pointed out, but by those who held that no definite compound was produced, this change was attributed to the direct oxidation of the hide substance and loss of nitrogen as ammonia. The above experiments go far to establish that when tannin is employed, the conversion of the hide into leather is due to a combination or condensation of the gelatin and tannin.

We have not been able to ascertain what is the maximum amount of tannin which a given weight of hide will chemically absorb, but many of the samples of leather prepared by the ordinary process contain less tannin than the above. It is obvious that, provided the quality of the leather is equally good, the tanner, instead of aiming at the maximum yield of weight, should strive at the minimum yield, when tannin is worth more per pound than fleshed hide, and conversely, when the economic conditions are reversed. The limits for a good leather appear to be approximately 40—60 per cent. hide substance, in union with 60—40 per cent. "tannin."

At present it is customary to judge of the quality of the leather from its appearance and color; a hide is, however, frequently struck through when it has only absorbed a comparatively small quantity of tannin, and the color of the finished leather varies considerably with the kind of tanning materials employed.

In Fig. 3 the daily absorption of tannin from the liquor in the above experimental tannage by this process is shown, in which it will be seen that the rate of absorption, as already shown in Table IV., gradually diminishes as the hide becomes saturated with the tannin, and finally the rate becomes so small that the ordinary permanganate valuation of the liquor is useless for estimating the change.

In Fig. 4 the daily readings for a similar experiment are plotted out and show analogous results. The readings were, however, discontinued on the 11th day, although the quantity of tannin absorbed by the hides used in this experiment was not sufficient to completely tan them. They were subsequently finished in another vat. From the foregoing results, we have sufficient data to establish the qualitative fact that the combined action of the motion and the electric current considerably hastened the rate of tannage. It was of interest, however, to ascertain, if possible, what was the average rate obtained when the hides were slowly rotated in the pit and when no current was passed through the liquor.

A comparative experiment was made to establish this point, the results of which are given in the accompanying diagram (Fig. 5). Two circular vats were employed, A and B, containing 1,600 and 2,400 gallons of liquor respectively, made up to approximately the same strength. A batch of hides which had previously been limed, unhaired, and fleshed under the same conditions, was divided into two portions, whose weights were in the ratio of the volumes of the liquor in the two vats, so that the loss of tannin per unit volume of the liquor is equal to the absorption of tannin per unit weight of hide in each vat. The liquor in both vats was analyzed at the commencement of the experiment (Feb. 14, 4 p. m.), and the hides remained suspended in the liquor, without any motion or electric current being applied to them, for 44 hours. Samples of the two liquors were analyzed and the rate of absorption in each vat deduced and found, as might be expected, to be practically identical. The subsequent treatment of the hides in the two vats was so arranged that the hides in vat 1 should be subject to the joint influence of motion and electric current, while those in vat 2 were under the influence of motion alone. The experiment was then repeated for a longer time, and after an interval of rest the conditions were reversed, the hides in vat 1 being subjected to motion alone and those in vat 2 to the joint action of motion and electric current.

The results are plotted together in Fig. 5, where the upper curves show the gradual loss of tannin from the liquor and the lower curves calculated from them to show the quantity absorbed by the hides (as during these experiments the liquors were not strengthened, the lower curves are the images of the upper). From the slope of the lines the relative rates can be obtained.

The following table summarizes the above results:

Comparison of the Rates of Tanning.

Kind of Tanning.	Total Loss in Parts per 10,000.	Total Time in Hours.	Rate.
Ordinary tannage	12·8	88	·145
Rest after motion and electric current	15·3	56	·273
Rest after motion alone	15·7	56	·280
Motion after electric current	8·6	24	·36
Motion alone	13·8	38	·49
Motion and electric current	53·6	38	1·42
Electric current after motion	59	24	2·47

Fig. 3.

Diagram of Complete Tannage. Groth's System.

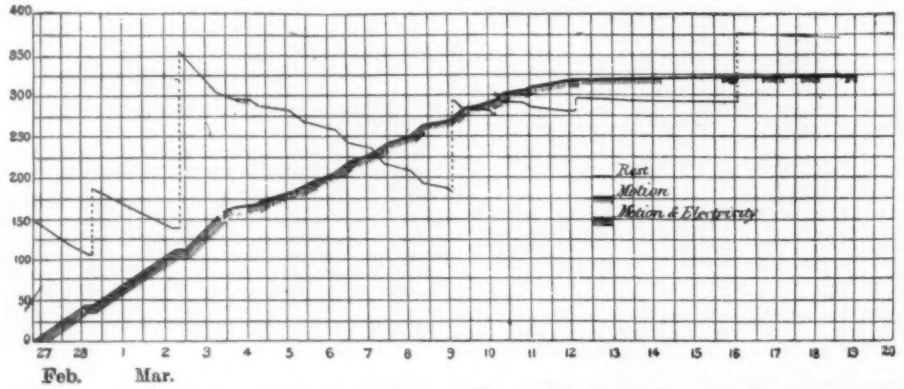


Fig. 4.

Diagram of Complete Tannage.

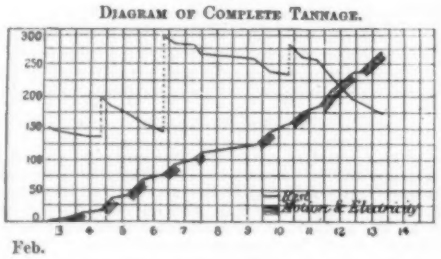
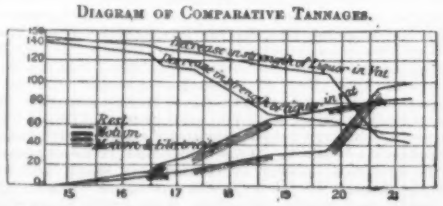


Fig. 5.

Diagram of Comparative Tannages.



Thus, while the initial rate in vat 1 was 0·163 part per 10,000 per hour, and 0·104 part per 10,000 per hour in vat 2, when a current of electricity and motion was applied to vat 1, and motion only to vat 2, the rate of loss in vat 1 rose to 2·43 parts per 10,000, and in vat 2 to 0·63 part per 10,000. After an interval of rest, vat 1 showed a rate of 1·36 parts per 10,000 and vat 2 a rate of 0·52 part per 10,000. It is to be noted, however, that the apparent falling off in the rate in vat 1 may be due not only to the gradual diminution as the tanning proceeds as already referred to, but to the electric current during the night of this experiment being smaller than during the day, or possibly interrupted for some time, as no electrician was controlling the experiment during the night in question. After an interval of rest the conditions were reversed, motion being alone used in vat 1, and motion and a current of electricity simultaneously in vat 2. The rates of loss were then found to be 0·36 part per 10,000 per hour in vat 1 and 2·46 parts per 10,000 per hour in vat 2, thus confirming the previous figures and proving that the vats or proportions of liquor and hide employed in each were not affecting the comparison.

The average values thus obtained are in the proportion of—

Ordinary Tanning.	With Motion.	With Motion and Electricity.
·133	·503	2·08

Or the rate of tanning under the combined influence of electricity and motion is four times faster than the rate when motion alone is employed, and sixteen times faster than when neither is used.

We have not tried the effect of a current of electricity on the hides when at rest, although no doubt the tanning rate would be similar to that obtained when motion is employed, as the hides when at rest would not be uniformly influenced by the flow of the current through the vat, and the leather produced would therefore be unequally tanned. It ought also to be noted that these rates were obtained with the motion of the kind produced by the first kind of machine, and that no doubt other rates of tanning would be observed under the influence of other kinds of motion, and if no provisions were adopted for preventing the hides from being in contact with another, it is safe to assume that the rate would be considerably less, as the

circulation of the liquor to every part of the hide would be prevented.

Theoretical Conclusions.—The original suggestion of Grothius in 1805, with its chain of molecules and bonds, its pairing and unpairing, formed a very fair working hypothesis, and has been gradually developed and elaborated until we are to-day confronted with a very serious complication of theories. Helmholtz has suggested that there is no tearing apart of the molecules, but that work must be done in separating an atom from its electrical charge, or in removing electricity from an atom of high specific attraction, and giving it to another lower in the scale. Clausius considered that the molecules are always changing partners, that dissociation, in fact, is always present to some extent, and that the effect of the electro-motive force is to give direction to movements which are already going on. Arrhenius considers that dissociation is complete in very dilute solutions, but Traube maintains that such a view upsets our conceptions of chemical affinity, and makes the convenient assumptions as to the nascent state impossible, and flatly contradicts the theory of hydration. The idea of a nascent state has been to a large extent given up by chemists, but the ions undoubtedly are occasionally liberated in a form in which, although they do not readily combine with the other matters in solution, and are in a self-combined state, *e. g.*, ozone, they are in a very energetic condition. From *a priori* considerations, as we have observed, this nascent state or the resulting facilities for combination which arise from the cause, whatever it is called, might be expected to facilitate the operation of tanning in the same way that it affects the operations of bleaching and treatment of sewage. But although the tannins are molecules of some complexity, there are no grounds for supposing that dissociated molecules react with the gelatin of the hides, and we have no proof whatever that any such dissociation takes place in the tanning process. Turning to the question of dialysis and osmosis, we find dialysis to be a form of diffusion to which electrolysis has been compared by Wiedmann, who showed that the conductivity of an electrolyte may be considered as depending on the coefficient of diffusion of the components through each other. Dialysis is a selective diffusion, and is undoubtedly facilitated by the passage of an electric current, and it is easy to see that such an action must be extremely advantageous in the slow process of tanning, which is probably retarded enormously by the superficial coagulation which takes place almost at the moment of first contact of the green hide with the tanning liquor.

Theories of dialysis are at present incomplete, but Van t'Hoff's law of osmotic pressure and our knowledge of the migration of ions indicate the direction from which a satisfactory theory of the process may be looked for.

In the meantime, the facts which have been established are of a very different order, so widely different indeed that hypotheses of osmosis and observations of the migrations of ions are alike useless. Dr. Oliver Lodge's experiments with dilute H_2SO_4 give a velocity of about $\frac{1}{1000}$ cm. per sec. for H and $\frac{1}{1500}$ cm. per sec. for SO_4. With jelly and a slope of potential of 1 volt per cm. the velocity of Ba was $\frac{1}{3500}$ cm. per sec. and Cl and Br $\frac{1}{1750}$ cm. per sec. But with a slope of one-tenth of this, *i. e.*, about 1 volt per cm., the rate of progress of tanning is only about 0·025 cm. in 100 hours, or $\frac{1}{12000000}$ cm. per sec. or 7½ inches per annum.

It thus seems necessary to attribute part of the hastening effect to the direct action of the electric current upon the suspended hide.

Helmholtz and Ostwald have given considerable attention to the resistance of electrolytes, and it is pointed out that the degree of dissociation can be determined from the conductivity. Arrhenius concludes that the resistance is greater as the ions are more complex, and the tannin molecules are considerably more complex than any compounds that have yet formed the subject of careful experimental work. Not only have we a complex solution, but it is admitted that with weak currents secondary actions are likely to take place at the electrodes, and it is only with strong currents that the real ions are liberated. The fact that the rate of absorption of tannin distinctly diminishes with even four amperes shows that if any chemical action be involved it is probably some secondary action of considerable complexity, and that, therefore, there is no need for attempting to explain the process by an electrolytic breaking down of the tannin molecules.

Although it is difficult to advance any definite theory as to the effect of the passage of the electrical current upon the process of tanning, the increased rate is obviously due to the current hastening the chemical union between the bodies which are in a condition to combine. It is well known that chemical combinations which only take place at elevated temperatures can be induced to occur at ordinary temperatures when an alternating current is passed through the mixture of the two bodies. Amines combine with aldehydes in this way, and Meritens (Eng. pat. 16,947, 1889) has proposed to bring about etherification, and so effect the quick ageing of spirits by the help of an alternating current.

Dr. S. Ehrmann, of Vienna, has also recently shown that a moist skin absorbs salts very rapidly from their solution when an electric current passes, and Wagner has also proposed to administer cocaine by a similar process of cataphoric medication. In Ehrmann's experiments, in which a current of 10—20 milliamperes was passed from zinc electrodes through a solution of methylene blue, in two cups in which the hands of the observer are immersed, blue spots appeared on the back of the hand in the anode vessel and none on the other hand in the other vessel. The absorption was most marked where the air and fatty glands are situated, and thus throws light on the fact that in tanning the process is most rapid on those parts of the skin, and that the electric current has no doubt a distending effect upon the pores of the skin, as indicated by our earlier experiments.

Lithium chloride is similarly absorbed by endosmosis through the skin, and Edison has shown that gouty secretions in the fingers are speedily dissipated by the prolonged action of currents of 20 milliamperes. H. N. Lawrence and Dr. Harries have obtained similar results (Soc. Arts, March 11, 1891). We believe that the hastening of the tanning process is of a similar character, and we draw attention to these experiments as analogous, if not confirmatory of the explanation of the process which we tentatively advance in this paper.

We have to thank Mr. Bawden, one of our assistants, and Mr. Fox Bourne for help in carrying out part of the experimental work of this paper.

DISCUSSION.

Mr. B. Hooper, speaking as a practical tanner of 50 years' experience, could corroborate Dr. Rideal's statement with respect to the difference of time required for tanning by Groth's electric system and by the ordinary process. He had been daily at the tannery while five parcels of English hides had been working under Mr. Groth's system, and had regulated the application of the tanning materials used, which were all the usual vegetable substances, and no chemicals. He would challenge any tanner now working the same class of hides to produce leather such as they saw before them in less than six or eight months by the old process, whereas this leather was tanned in three weeks. All the other processes of quick tannage which had come under his notice had failed to produce leather equal in weight to that made by the old process; but tanning by the aid of electricity gave results as to weight of leather produced, color, and quality fully equal to those produced by the ordinary method; and it was clearly demonstrated by Dr. Rideal that the saving in time was effected only by the aid of electricity.

Mr. W. F. Anderson was under the impression that the effect of electricity was to distend the skin, thus causing the fiber to be more open than usual. Perhaps that accounted for the advantages of the process. At the same time, he understood that electricity had a contractile effect on muscular tissue. He would be glad if Dr. Rideal could explain that point, for although it might not appear to have much to do with the subject, yet the fact remained that they had these two kinds of tissues on which it would seem that electricity had directly opposite effects.

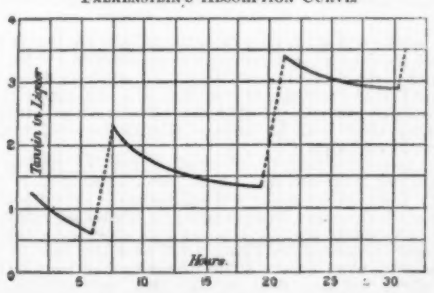
Mr. J. Swinburne congratulated the authors on attacking so difficult a subject with so much success. He thought that the first thing to settle was whether tannin was an electrolyte or not. He would suggest that its penetration through some such neutral substance as agar jelly should be tried, with and without a current. The authors had argued that the electric current deposited tannin in the same way as it deposited copper in Ostwald's experiment. He thought there was no analogy; copper was the electropositive radical of an electrolyte; tannin, if not a colloid, was either the whole electrolyte or the electro-negative radical recombined with hydrogen. Copper was frequently deposited on the porous pots in Daniell cells; but, he was informed, this occurred only when the zincs touched the pots, in which case it would not be the same phenomenon as Ostwald's. The authors had been led to look for mysterious actions, because they assumed that such a small current as that used could work such a quantity of tannin into the leather. They argued that one coulomb could only urge one electrical equivalent of tannin into the leather.

The matter seemed to admit of very simple explanation. Suppose a dozen skins to be stretched across the vat at a given time, and an equivalent of electricity to pass, it would work, not one, but 12 equivalents of tannin into the skins. But if mechanical agitation were applied, it would work tannin into the interstices of the skins, and if then electricity were applied, it would cause the tannin to diffuse, or penetrate into the various mechanically impervious walls of the interstices of the hides. The result was that when combined with mechanical agitation, a very small current was necessary to tan a large quantity of hide. There was no need to rely on obscure actions, such as deposition of films, or the suggested opening action of electricity on the pores of the hides.

Mr. Conrad K. Falkenstein said that during the last two years he had been working on the subject of electric tanning by a different process to that employed by the authors of the paper, and was, therefore, pleased to see the way in which they had worked out the problem. He had traveled over much of the same ground, especially with respect to the results given in Fig. 3, and his results were almost identical with theirs, except with regard to the small absorption curves showing the variation in the strength of liquor during the process of the tannage; the difference being due to the greater rapidity of the method employed in his experiments. A point in which he differed from the authors was in respect to the distribution of potential in the liquor of the drum employed in the Worms & Bale process.

His own experiments showed that at any given point in the liquor the potential was proportional to the distance of that point from the electrode, and that there was a perfectly even distribution of the potential right across the drum. (Diagram given illustrating this point.) With respect to the variation of resistance with the current density, his experience agreed fairly well with that of the author's. In a four hours' test, the current remaining the same, the potential dropped to nearly half the amount, the drop reaching its maximum at about half time, and then remaining fairly constant to the end of the experiment. He considered that the effect of the current on the liquor was undoubtedly electrolytic, but the amount of electricity passing being very small, the effect was but slight. But it was certain that there was a definite relation between the amount of electricity passing through the liquor and the amount of tannin that became inert or was oxidized by the oxygen evolved at the positive pole.

FALKENSTEIN'S ABSORPTION CURVE.



He very much admired the way in which the author's experiments had been carried out, and the manner in which they had thrown light on the subject.

Mr. A. P. Trotter, referring to Mr. Swinburne's statement that the particles of the leather being in series, the action which took place in one hide would follow naturally in another hide with the same current, pointed to the very small quantity of hydrogen evolved, and stated that only fifteen millionths of the liquor was decomposed, so that it was hardly possible to imagine that the action was electrolytic. An idea had been put forward that dialysis or osmosis might explain the effect produced; but the calculated speeds of the migration of ions were of such a different order that that theory would not hold.

He was inclined rather to the old-fashioned idea of dialysis which had been ousted by the recent hypotheses of osmosis. But all that could be said was that dialysis was hastened by the passage of a current. He, therefore, thought that both the electrolytic and the osmotic theories must be put aside until we had more knowledge about the subject. The result shown on the lower diagram (Fig. 5) indicated that it would be better to apply motion first and electricity afterward, in order to get the most rapid tanning effects. The current density was so small that it could hardly account for the physiological effects referred to by Mr. Anderson.

Mr. J. Swinburne thought Mr. Trotter had misunderstood his argument. It depended not so much on the hides being in series as the various particles of each hide being in series. At the slow rate at which radicals moved, it was impossible for the tannin to be driven through a hide in the time, but if it were worked mechanically into contact with a cell, electricity would drive it in.

Curve 5 showed that the current should not be turned on till the liquor had been thoroughly worked into the interstices of the skin. The electricity then took particles or fibers into the interior of the various cells and tanned the hide. If the electricity were turned on at first, it tanned the outside and partially hardened the skin, so that mechanical agitation then failed to work the liquor farther in.

Dr. S. Rideal, in reply, said that with respect to the question put by Mr. Anderson, he could not see that the two effects were in any degree comparable, as the microscopical structure of skin showed that it was different to that of muscular tissue. In the paper they had referred to recent physiological experiments which seem to bear on the phenomena under discussion. He was glad to hear from Mr. Swinburne that, speaking as an electrician, there was no difficulty in accounting for the deposition of the tannin upon the hides. He had not known that Mr. Falkenstein had been working in the same direction as they had; and it was all the more satisfactory, therefore, to find that their results were mutually corroborative.

SILVA JARDIM.

OUR readers know of the frightful accident by which Mr. Silva Jardim, a Brazilian politician, lost his life.

SILVA JARDIM.

In an ascent of Vesuvius that he was making on Thursday, July 2, in company with Mr. Cameiro, of Mendouca, he was desirous by all means, despite the protests of his friend and the accompanying guides, of going close to the great crater. All at once a crevice opened under his feet, and he disappeared in the abyss. Nothing but a column of dust and smoke indicated the place where he had just been entombed.

Mr. Jardim was one of the most eminent political men of the young republic of the United States of Brazil, not only by his talent and the prestige of his eloquence, but also by the number of services rendered the republican cause.

His political career began in 1888, and, although it was short, was most brilliant. From January, 1888, to November 15, 1889, the date of the proclamation of the republic, he found time to travel successively over the provinces of Saint Paul, Rio de Janeiro, and Minas, and go from city to city carrying the republican propaganda, organizing public conferences, encouraging his fellow reformers, rallying the undecided and sometimes even the adversaries.

He was several times threatened with death, but he feared no danger, says our distinguished confrere, Mr. Oscar d'Aranjo, to whose kindness we owe these data.

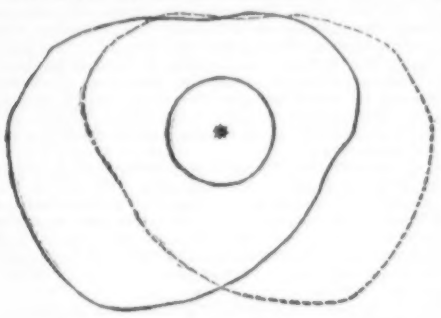
On returning to Rio de Janeiro, where he practiced law with much distinction, he did not cease to work on the republican propaganda. On the day of the revolution he was among those who, with Messrs. Jose de Patrocino and Annibal Falcao, proclaimed the republic at the city hall. His name, which was at first mentioned for a portfolio in the provisional government, was set aside at the last moment. Moreover, he soon found himself at loggerheads with the government of the state of Rio de Janeiro, in which he presented himself at the elections for the Constituent As-

sembly with a list of opposition which was beaten in a lump.

After this repulse, he came to France to study our republican institutions more closely. His death was felt in Brazil as a national affliction.—*L'Illustration.*

A PHOTOGRAPHIC VIEW AND THE HUMAN EYE.

I SHOULD like to draw a comparison between a photographic view and the field of vision of the human eye. The dotted lines in the figure represent the limits of the field of vision of the right eye as projected on the interior of a hemispherical surface; the continuous line, that of the left eye; and the central circle the limits of a photographic picture, *i. e.*, 45°, all taken from the same point, the center of the spherical surface, the camera in the one case, and the eye of the observer in the other case, being exactly opposite the fixation point, as represented by the star. We see at a



glance how limited in extent is the photograph as compared with the field of either eye, and further, as the writers told us, how the upper and lower halves of the field of vision differ in size and shape.

In contrast with *extent of surface*, however, we find that the photograph has an immense advantage over the eye in the *definition of eccentric objects*, which are practically as clearly figured as those directly in the center. That this is far from being the case with the eye may be easily shown by fixedly regarding, at a distance of about twelve inches, any one letter of a word in this page, when it will be found that, at most, two letters on either side can be recognized. It follows from this that any drawing represents the aggregate of an enormous number of separate observations by the artist of different portions of his study, for if he were to endeavor to draw only what he saw when fixedly regarding one part of his study, let us say a life-sized portrait, the result would be one waistcoat button as natural as life, and the rest chaos, but he would have the satisfaction of having faithfully rendered what he saw. All the cases of distortion mentioned by the ingenious writers occur only in the single fixation observations, and hence can have no bearing in any kind of drawing.—*A. Hill Griffith, M. D., in Photography.*

COMMON OBJECTS AVAILABLE FOR EXHIBITING THE POWER OF THE MICROSCOPE.

By F. BLANCHARD, M.D.

To the amateur microscopist it must often occur to exhibit the power of his instrument to friends who are not familiar with it. On such occasions the selection of unsatisfactory objects is most disappointing. The foot of the common house fly, although a wonderful structure, has been described so often in juvenile literature that the audience is apt to yawn over an explanation of claws and suction disk. So with the circulation of blood in the frog's foot, the rabbit's ear, and the salamander's tail. So with the irrational motions of amœbæ in Potomac water.

It is the unpretentious object of this item to enumerate some other readily obtainable objects for extemporaneous use on such occasions. They require no elaborate preparation and no reagents.

The feathery dust from the wing of the "dusty miller" is, perhaps, too commonly used to need mention. The feet, eyes, antennæ, and wings of cockroaches, bees, wasps, mosquitoes, and butterflies furnish a great variety of wonder-inspiring views.

Often you will be compelled to disappoint some one who expects to see "lots of little bugs" in a drop of well water, but a drop of slime from the under surface of a lily pad will fully meet such expectation.

The tail of the newt still remains the most convenient object for showing the circulation of blood. In the same jar where the newts are kept a few sprigs of chara should be kept growing. The stem of chara shows cyclosis beautifully. Thin peelings from the bulb of the common onion also show sap circulation well. In cold weather the onion should be kept in a warm place a few hours to quicken the circulation of the sap.

Cross sections of common woods make interesting specimens. They can be cut with a keen jack knife, if one has the "knack." Cornus stolonifera, a shoot ¼ inch in diameter, makes a good one to begin on, but any soft wood will answer.

Stellate and glandular hairs of plants, the breathing pores of such plants as the white lily, the translucent leaves of mosses, and the pollen of flowers should not be forgotten.

Minute seeds, with their infinite variety of form and marking, are things of beauty and a joy forever. They require a condenser, but no cover glass. Try the seeds of Arenaria serpyllifolia, and you will be encouraged to seek further. A most delightful series of objects can be easily made from the small seeds of Caryophyllaceæ. The genus Euphorbia furnishes another fine series in which you can often determine the species by the seeds alone. Juncus gives us still another series. In J. effusus and J. bufonius the ribs and cross lines of the seeds are delicate indeed.

The pappus of many species of compositæ is a charming sight under the microscope, especially when the pappus is plumose, as in kuhnia, the thistles, etc.

Most of the common grasses have plumose stigmas, which, with their coloring of purple, show finely with objectives of moderate power. The hairy palets of grasses make first-class objects.

Lycopodium, the powder which druggists use to keep pills, etc., from sticking together, will prove of interest and is easy to obtain. It consists of the spores of the common club moss or evergreen. The spores move over each other so freely that the powder in bulk shakes like a liquid. To the touch it seems like an oily liquid. But under the microscope it appears as innumerable yellow globes, somewhat shrunken and irregular when dry. Any species of lycopodium will furnish a supply from August to October. The spores of ferns and mosses are equally interesting.

But if you wish to elicit from your audience exclamations of delight, put on the slide a freshly ruptured spore case of one of the larger Hepaticæ. Marchantia, asterella, or conocephalus will answer. The lively way in which the spiral elaters toss the spores about is sure to "bring down the house."

Diatoms you will find in abundance in the stomach of the oyster; but a more convenient source is common polishing powder, which consists largely of their remains.

Raw silk, cotton, and wool, hair and feathers, are rich spoil for the amateur exhibitor of the microscope. Common drugs, like morphine, quinine, and strychnine—you need not go far for ready-made objects.—*American Microscopical Journal.*

THE ABERRATIONS OF SOUND.

DR. WELLING, president of Columbian University, in a paper read before the Washington Philosophical Society, November 5, 1881, said:

In a paper presented to the Royal Society in 1874, Professor Reynolds showed that the form of the sound wave is liable to flexure from changes in the temperature of the atmosphere, as well as from the unequal motion of the wind. These abnormal phenomena of sound, considered in connection with the hypothesis of Professor Stokes, as enlarged and applied by Professor Henry, may be reduced in the following generalizations, which, if accurate in point of logical form and true in point of the facts to which they are applied, may be stated under the guise of aphorisms, as follows:

1. Where the condition of the air is nearest that of a calm, the larger will be the curve of audition, and the nearer will the shape of the curve approach to a circle, to which the point of origin of the sound, or the point of perception, will be the center. (This aphorism is stated abstractly from any consideration of temperature refraction, which, so far as it exists, will always tend to modify the shape of the curve of audition.)

2. Apart from all consideration of temperature refraction, a sound will be heard farthest in the direction of a gentle wind, because the portion of the sound wave thrown down from above in this case is re-enforced by the sound reflected from the surface, and will thus more than compensate for the loss by friction.

3. Other things being equal, the area of audition will be proportionately diminished in the case of sounds moving against winds more or less strong, because the sonorous waves will be refracted above the ears of the observer.

4. The area of audition will be diminished in the case of a sound moving with an overstrong favoring wind, because the sound waves in this case will be so rapidly and strongly thrown to the ground that the intensity of the sound will suffer more diminution from absorption and friction than can be supplied by the upward reflection of the sound rays conspiring with the gradual downward flexure of the sound waves, as in the case of a gentle favoring wind.

5. Sounds moving against a gentle wind will, *cæteris paribus*, be heard farther than similar sounds moving with an overstrong favoring wind, for reasons already implied, because the downward flexure of the sound waves, being excessive in the latter case, tends to extinguish the conditions of audibility more rapidly than is done by the slight upward refraction in the former case.

6. When sounds moving against the wind are heard farther than similar sounds moving with a wind of equal strength, it is because of a dominant upper wind blowing at the time in a direction opposite to that at the surface.

7. A sound moving against the wind, and so refracted as in the end to be thrown above the head of the observer, will, at the point of its elevation, leave an acoustic shadow. But this acoustic shadow, at a still further stage, may be filled in by the lateral spread of

Area of Audibility. Area of Inaudibility. Area of Audibility.

the sound waves, or may be extinguished by the downward flexure of the sound waves, resulting from an upper current of wind moving in an opposite direction to that at the surface, or resulting in a less degree from an upper stratum of still air. Under these circumstances, there will be areas of silence inclosed within areas of audition.

8. As sounds may be refracted either by wind or by changing temperatures, or by both combined, it follows that, under many circumstances, a sound lost at one elevation may be regained at a higher elevation.

9. As sounds moving against the wind are liable to become inaudible (by being tilted over the head of the observer), even before their intensity has been extinguished, we may find in this fact an explanation of the statement made by Reynolds that "on all occasions the effect of wind seems to be rather against distance than distinctness."

10. As sounds may be inaudible at certain distances and elevations, without being wholly extinguished, it follows that the comparative inaudibility of sounds at different times cannot always be cited as an evidence of their relative intensities. The comparative inaudibility may be a function of variable refraction rather than of variable intensity. Hence the law of inverse squares, though perfectly true in its theoretical application to the measurement of the intensity of all sounds, cannot always be legitimately used to calculate backward from the audibility of a sound, as empirically ascertained at a given point and elevation, to its relative intensity as previously heard at the same point and elevation.

11. The hypothesis of Stokes, applied by Henry, does not exclude the hypothesis of Humboldt, but reduces the latter to a very subordinate and inappreciable place in interpreting the abnormal phenomena of sound.

12. The hypothesis of Stokes, as applied by Henry, does not exclude the reasoning of the experimental proofs by which Professor Reynolds demonstrates that differences in temperature exert a refracting power in sound, but finds in that refraction an influence which may sometimes accelerate and sometimes retard the refraction produced by wind.

URIC ACID IN DISEASES OF THE NERVOUS SYSTEM.

IN the quarterly journal, *Brain*, spring number, 1891, Dr. Haig gives an interesting and instructive *résumé* of the influence of uric acid upon the system, and particularly upon nervous tissues.

As is well known, Dr. Haig has given great attention to this subject, and has made the influence of uric acid on the human economy the subject of extended and careful investigation. His statements, therefore, should command attention, and we are sure that a brief *résumé* of his conclusions cannot fail to be of value to our readers. (*Cincinnati Lancet Clinic*, June 20, 1891.)

He first quotes the statement of Sir A. Garrod, that "the causes which predispose to gout, independently of those connected with individual peculiarity, are either such as produce an increased formation of uric acid in the system or lead to its retention in the blood."

Dr. Haig's investigations have led him to discredit the former of these causes and to attribute all uric acid diseases to its retention in the blood and in the tissues. He prefers the terms uricæmia or uric-acidæmia to designate these conditions. He is in accord with Murchison in his description of lithæmia as the symptomatology of uric-acidæmia, but does not attribute these to disturbed action of the liver, holding that the liver symptoms are concomitant or secondary and are the results of excess of uric acid, and he further believes that this excess is due to the failure to excrete it in the normal proportion of one to thirty-three of urea.

His investigations relating to the causation of migraine are detailed at considerable length. His attention being called to the relation of migraine to gout by Liveing and others, he discovered that the urine secreted during a headache always contains a considerable excess of uric acid in the proportion of one in twenty or one in twenty-five to the urea, while that excreted immediately before the attack of headache began contains a diminished quantity—one in forty to the urea. Aching pains in the limbs, lassitude, and depression of spirits he finds quite common in uric-acidæmia.

Noting the statement of Sir A. Garrod as to the action of beer and wine in producing gout, he tested these and found them strongly acid. This led him to experiment with acids and alkalies, and, as he says, "I found, to my surprise, that I was able to alter the excretion of uric acid in either direction at pleasure." He then soon found that he could, by influencing the excretion of uric acid, also influence the headache as well, acids relieving or removing the headache, while alkalies made it worse. He also found that by giving acid for a day or two he could store up the uric acid in the tissues, and then by giving an alkali could wash it out into the blood and urine and bring on an attack of headache at will.

Since that time he has been able to show that "if uric acid is previously removed by a course of salicylate of sodium, a dose of alkali will produce neither a plus excretion of uric acid nor a headache." From this he infers that the headache is proportional to the uric acid in the urine, and that "the amount of this in the urine may be regarded as an index of the amount in the blood."

The relation of migraine to epilepsy led him to investigate this disease, in which he found a minus excretion of uric acid preceding a fit and a plus secretion accompanying.

The relation of mental depression and mental exaltation to this variation in uric acid excretion also engaged his attention. He was able to connect the exaltation with its diminished excretion and depression of spirits with its increase.

The "intense and persistent coldness of the hands and feet in an attack of migraine" led him to note that "the pulse was slow and the vessels full during the attack." The tracings which he has accumulated conclusively prove, as he thinks, that he has "practically complete power over the rate and tension of the pulse." He states that "arterial tension varies with the amount of uric acid in the blood when combined with alkali (soda or potash), but is little affected by it, even though present in considerable quantity, if combined with a salicylate (salicyluric acid)." He thinks that opium produces its well known effects on the mental condition through its effect on the circulation of the brain, which is secondary to its effect on uric acid, and that this depends on its influence on the alkalinity of the blood, and so on the solubility of the uric acid.

The chief substances which diminish the excretion of uric acid in the urine are "acids, iron and lead, and opium, and those which increase it are soda or potash under certain conditions, phosphate of sodium and salicylates." Mercury, he states, also markedly reduces the excretion of uric acid in the urine, reduces the tension of the pulse, and produces diuresis.

In the removal of the uric acid headache, which he thus attributes to the local vascular effect of the uric acid upon the blood vessels of the brain, he places great value upon a regulation of the diet, "one of which milk, fish and eggs constitute the only animal food completely removing the attacks, and without the use of any drugs whatever." "I believe that a man eating meat three times a day, and drinking acid beer and wine, may keep back and store up in his body several ounces of uric acid in a few years, while

on the above diet he would not store up as many grains."

He mentions that Professor Lange, of Copenhagen, connected certain conditions of periodical depression with the uric acid diathesis, and treated them successfully by a diminution of meat foods, etc., and that Dr. Broadbent notices the frequent association of melancholia and mental depression with high tension of the pulse, and records their successful treatment by the milk diet. He believes that "many a case of suicide, and some murders, might be prevented by a timely dose of acid which would free the brain circulation from the power of the acid."

THE RED OAK.

THE red oak is one of the largest and most beautiful of the deciduous trees of the American forest. It is the largest and the most widely distributed American representative of the so-called black oaks—that is, of the oaks distinguished by the acute bristle pointed lobes of their leaves, by the slow development of their fruit, which requires two seasons in which to reach maturity, and by their brittle and porous wood. There is no other American oak of wide distribution which varies so little as the red oak in the form of its leaves and in the character of its fruit; and it is in western Texas only that it occasionally assumes an appearance which is puzzling to botanists, leading them to suppose that through this extreme form it may be possible to join it specifically with some of the other black oaks.

From Canada to Texas the red oak varies but little in what may be called essential characters; individuals are large when the soil is rich and moisture is abundant, and they are small and stunted in barren soil unrefreshed by copious rains. The leaves and the fruit are larger and better developed when conditions of growth are favorable, but in form they are very constant, and is is easy to distinguish the red oak, with a little practice, at all seasons of the year.

In habit of growth it varies considerably, but not more than other trees; for it must be remembered that the habit of a tree—that is, the form of growth a particular individual assumes—is dependent entirely on the local conditions and surroundings in which the individual is developed. It is exceptional when all the individuals of a tree species assume the same habit of growth. Most trees form tall slender stems when other trees crowd them, as in the forest, and cause their lower branches to die from the insufficient supply of sunlight which reaches them. An individual of the same species standing by itself will send out long stout lateral branches, which give to the tree an entirely different appearance. In the case of some trees the habit of individuals is influenced by the character of the soil in which they grow, and age, of course, brings many changes in form and general appearance to trees. It is for these reasons that the portrait of an individual gives only a partial and therefore an unsatisfactory idea of the general appearance or habit of the species, and why a hundred portraits would be necessary to give anything like a comprehensive idea of the appearance of a tree like the red oak, for example, as it appears in different parts of the country growing under the different conditions to which it is subjected.

The power to recognize trees at a glance without examining their leaves or flowers or fruit as they are seen, for example, from the car window during a railroad journey, can only be acquired by studying them as they grow under all possible conditions over wide areas of territory. Such an attainment may not have much practical value, but once acquired it gives to the possessor a good deal of pleasure which is denied to less fortunate travelers.

The red oak (*Quercus rubra*) grows naturally in both rich land and in light porous gravel. Usually it selects a soil intermediate in character between that preferred by the white oak and the sterile soils occupied by the black oak. It is the only oak which reaches as far north as the northern part of Nova Scotia, while westward it extends almost to the limits of the Atlantic forest region. It is one of the commonest trees in all this great territory, and grows from the immediate neighborhood of the coast to higher elevations on the Appalachian Mountains than any other oak tree; it is as common west of the mountains as it is on the Atlantic seaboard, and it abounds in the South as well as in the North. The red oak cannot secure a foothold in undrained swamps or on the inundated banks of rivers, but in all other situations, from Cape Breton to the Rio Colorado, it can hold its own wherever trees grow. It is west of the Alleghany Mountains that the red oak, growing on rich intervale lands along the larger streams which flow into the great tributaries of the Mississippi, can be seen at its best as a timber tree. Here specimens can be found a hundred and fifty feet high, with stems as straight as arrows, free of branches for sixty or seventy feet from the ground, and five or six feet in diameter, above the great swollen buttresses which are characteristic of large individuals of this species. Such noble specimens occur, too, in the forests which clothe the slopes of the mountains of the South, but at the North, where the deciduous forests which Europeans found here when they discovered America have been replaced by a second growth, the red oak assumes, usually, a different habit. The trunk often separates, fifteen or twenty feet from the ground, into several stout branches which grow in an upright direction, and, gradually spreading outward, form a wide head in the shape of an inverted pyramid. Such a form indicates that the tree has grown in good soil and that it has succeeded in securing a fair amount of space in which to develop its head. In poor soil, and when crowded by other trees, the red oak makes a narrow head of small branches and does not grow to a large size. Sometimes it branches low, sending out at right angles with the trunk great wide-spreading limbs, like a pasture white oak, making a round-headed top. Such specimens are not common, and perhaps represent the noblest type of individual beauty the species is capable of.

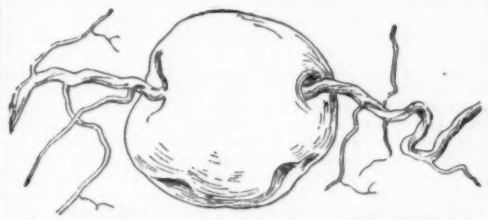
The bark of the red oak is dark brown and deeply furrowed on the trunks of old individuals; it is smooth and gray on young trunks and on the branches, unless they are very old and large. The bark of the branches is smoother and lighter colored than that of the other black oaks which are usually associated with the red oak, and for this reason the tree can be easily recognized in winter by the color of the branches alone. The leaves are oblong in general outline, with five or six acuminate lobes on each side, separated by rounded shallow sinuses; they are rather thin, smooth, bright shining green on the upper surface, and shining, although somewhat paler, on the lower surface. They are borne on long slender stalks which, like the upper side of the veins, are sometimes tinged with red; and in the autumn they turn first dull red and then yellow before falling. The fruit is unlike that of our other oaks. It is sessile or very short stalked; the cup is flat or shaped like a shallow saucer, with a narrow raised border of small, close fitting scales, and is often more than an inch across, inclosing the base only of the large oblong or ellipsoidal acorn, which is as long or longer than the cup is broad. The fruit is produced generally in great profusion, and in October often covers the ground beneath the trees.

The wood of the red oak, although strong and heavy, is coarse grained and difficult to season; it is light reddish brown and contains the bands of large open ducts found in the wood of all the black oaks. Formerly it was little used, but of late years, since white oak has become scarce and expensive, it is employed in great quantities in cooperage, in the manufacture of cheap furniture, especially in some parts of the West, and for the interior finish of buildings, for which purpose, when "quarter sawed," it is well suited and now highly esteemed.

The red oak grows rapidly. Very few of the American trees which produce hard wood increase in height and in girth of trunk as rapidly. Mr. Emerson, who devoted much attention to studying the rate of growth of different trees, found that the average increase of the red oak in Massachusetts during the first thirty-five years of its life was at the rate of about two inches in diameter every eleven years. In more favored parts of the country it would probably grow more rapidly. As a street or park tree the red oak is not surpassed in value by any of our trees, and it is surprising that it is not generally planted. There is, however, a popular belief that oaks are hard to transplant and that they grow very slowly. White oaks are certainly difficult to move, and must be set as seedlings if they are to grow into fine trees. But all oaks grow rapidly when once established, and there is no tree easier to transplant than the red oak. Specimens ten or fifteen feet high can be moved with perfect safety from the woods, and if they are planted in good soil will make for many years an average annual upward growth of eighteen or twenty inches. If hardiness, good habit, adaptability to different soils, beauty of foliage, longevity and freedom from disease have any weight with planters of trees, the red oak should receive attention at their hands. It is valued in Europe, where, especially in Germany and in Belgium, it is more frequently seen, and in better condition, than any American oak. But how many Americans plant oak trees or realize when they send to nurseries for foreign trees that their own town contains the best material for their ornamental plantations?—*Garden and Forest.*

POTATO PERFORATED BY COUCH.

SPECIMENS such as that seen in the sketch are occasionally sent to us, and have been figured at various times. We have now the opportunity of doing what



POTATO PERFORATED BY COUCH GRASS.

we have previously been unable to do, giving a correct explanation of the phenomenon, which always excites surprise. The roots of plants are formed within the substance of the plant, and make their way out from the center to the circumference, not only (if at all) by pressure exerted during growth, but by secreting a digestive ferment, which softens and dissolves the tissues and allows of the emergence of the root. Now the roots of the couch coming into contact with the potato exercise a similar property, and are thus enabled to penetrate the tuber. This is no theory, but has recently been demonstrated by a French experimenter, whose name we have unfortunately mislaid.—*The Gardeners' Chronicle.*

MANDIOCA.

By THOMAS MORONG.

WHILE in Paraguay in 1889, I was much attracted by this plant as a food product, very common in that country, and wrote a short article upon the subject, which was published in the *Bulletin of the Torrey Botanical Club* for October of that year.

In that article the opinion was expressed that the mandioca would probably thrive in our Southern States as well as in South America. At the time of writing, no information had reached me that the plant had been introduced into Florida, and was there in successful cultivation. Since returning to the States, I have seen an article written by Mr. H. W. Wiley, of the Agricultural Department at Washington, and published in *Agricultural Science* for October, 1888, from which it appears that this vegetable has been grown in Florida for several years under the name of "sweet cassava," and is regarded by the cultivators as an esculent of the highest value. In this article, Mr. Wiley gives the results of a careful chemical analysis of the properties of the cassava, which I shall compare with a similar analysis made by the municipal chemist of Asuncion, Paraguay, Senor I. D. Anisits, and which he authorized me to use for publication in this country.

The Florida correspondents of Mr. Wiley speak enthusiastically of the plant as a vegetable, its enormous yield, its culinary qualities and its value for domestic animals. All that they say fully confirms my own statements of its inestimable importance to the poorer classes of South America, and my predictions as to its estimation, should it ever be introduced into the United States and used as extensively as it is in the equatorial regions of the new world.

It would not be possible for me to give in these columns an exhaustive account of this remarkable plant. It would require a volume to do justice to the subject. I may, however, gather up succinctly the scattered remarks which have been made by various authors concerning its history, its uses, botanical characters, growth and propagation, its chemical and supposed medicinal properties, and embody in the relation my own observations upon these points.

It is not known where or how the mandioca originated, or at what period it began to be employed for domestic purposes, but there is some reason for supposing that its native home is the Guianas, and it is known that the plant was cultivated by the Indians in these provinces, and in Mexico, before the conquest, early in the sixteenth century, and in all probability, centuries before that. Humboldt and St. Hiliare believe that *Manihot pusilla*, of the Province of Goyaz, in Brazil, was the ancestor of all the forms now regarded as belonging to the genus. At all events, the cultivation and use of the plant have extended into all the tropical and sub-tropical countries of America, including the West Indies and Florida. It has also found its way into Africa and Asia, large quantities of the root being consumed in the "Straits Settlements," so called. The exportation of tapioca from Penang and Singapore amounts annually to 4,000,000 kilogrammes.

It is known under various popular names, being called *mandio*, *manioc*, and *mandioca* in Argentina, Paraguay, and Brazil; *yuca* in Peru, Ecuador, Bolivia, and Guatemala; and *cassava* in the East Indies, West Indies, and the United States. Botanically, it belongs to the *Euphorbiaceæ*, and has been known under the generic names *Manihot*, *Janipha*, and *Jatropha*. Seventy-one species are enumerated by Mueller in the Flora Brasiliensis, besides a considerable number of varieties which have received different native appellations. There can be no doubt, however, that a more careful scientific discrimination would reduce this enumeration at least one-third, if not even to a greater extent. For our present purpose they may all be divided into two classes, the poisonous and the innocuous. The principal species of the poisonous group is *Manihot utilissima*, Pohl., or, as it is commonly called in Paraguay, "Mandioca brava." The chief form among the harmless group is *Manihot Aipi*, Pohl., or the "Mandioca dulce." Both comprise various species or varieties, and both are extensively cultivated and used in the culinary arts. In the Guianas and Brazil, *M. utilissima* is most commonly used, while in Paraguay I found that *M. Aipi* is the general favorite, although both sorts are raised. Large fields of the sweet kind may be seen throughout Paraguay, and daily one may find immense piles of the roots upon the floors of the markets of Asuncion, brought in for sale by the country market women.

The toxic principle of the first class lies entirely in the juice, and is due to the presence of hydrocyanic acid; it is so active that cattle are quickly killed if allowed to eat the root, and one-half of a drachm of the freshly expressed juice is said to be sufficient to cause the death of a man.* The acid, however, is extremely volatile, and is easily removed by heat or fermentation. By completely expelling the juice, the mandioca brava becomes just as innocuous as its congener. I often heard the Paraguayans assert that they preferred the brava for flour and starch, but Mr. Anisits states that the dulce yields a much larger percentage of starch than the other, and that the tapioca, flour, and bread made from it are much superior. However that may be, it is a fact that the poisonous kind is preferred in the northern countries of South America, and is consumed in larger quantities by the inhabitants.

The process of preparing the mandioca meal is substantially the same throughout the continent as that employed by the Indians of Guiana, who resort to a very primitive method. The roots are carefully washed; then peeled and scraped with a knife, or a rasper made of an oblong board which is studded with small fragments of stone. The paste is afterward forced into a long narrow basket, which is suspended upon a hook in the roof, or from the limb of a tree. A pole is thrust through a loop at the lower part of the basket, one end of which rests upon the ground, where it is fastened by a heavy weight. A woman seats herself on the other end of the pole, and thus the basket is subjected to strong pressure. The juice is thus strained through the meshes, and drips into a bowl placed underneath. It is then suffered to stand in the sun and ferment, when it is drank as a highly relished intoxicating liquor known in Brazil as *tucupe;* or it is boiled until it becomes a kind of treacle, called *cassareep* in Guinea. After the juice is all drained off, the contents of the basket are taken out, dried and sifted through a coarse sieve, becoming a coarse heavy darkish meal. This is either wrapped in leaves and put away for future use or roasted over the fire on a flat stone as griddle cakes. The cakes may be eaten fresh, or dried in the sun, when they become hard and crisp with a flavor like that of freshly gathered nuts. To reduce this meal more finely it is ground or pounded in a mortar, and thus made into flour, which is called in Brazil and elsewhere *farinha*. Thus prepared the farinha is sold and used in Paraguay in the same way as our flour in making bread. The *chipa*, as the bread made of it is termed, is, when fresh, a very palatable and nutritious article of food. Tapioca is made by mixing the grated and pressed mandioca with water, and passing again through a sieve, when the pulpy fluid which flows through is left to stand and settle. The deposit soon hardens into grains which form the tapioca of commerce. In Brazil and Guiana another use is made of the cakes which I never saw practiced in Paraguay. They are converted into *paiwari*, an intoxicating beverage of which the Indians are inordinately fond, and of which they quaff large quantities at their fetes and drinking bouts. It is prepared by a process that cannot seem very pleasant to our civilized tastes.

The bread designed for this purpose is baked or burned until it is almost black, when it is broken into small pieces and mixed with water in a large jar. The larger fragments are picked out and chewed by the women while they are moving about and engaged in household occupations, and afterward thrown back

* Hieronymus, Pl. Diaph. Fl. Arg., p. 450.

into the jar. When the vessel is filled, its contents are poured into a trough and allowed to stand for several days until well fermented. The mastication is said to accelerate the fermentation, and to greatly enhance the flavor of the liquor. The result is a thick, brownish fluid looking like coffee mixed with milk, and having a sub-acid but not disagreeable taste. This habit of chewing the substance and mixing it with human saliva, repulsive as it is, seems to have a peculiarly fermentative effect, for it is practiced in other parts of the world in the preparation of stimulating drinks. The South Sea Islanders prepare their *khava* in this manner, and the Mexicans their *pulque*.

In the East Indies, where modern machinery has largely supplanted hand labor, the process of manufacturing flour and tapioca from the mandioca root is conducted much more rapidly and effectively in steam factories. The roots are placed in revolving cylinders, where they are thoroughly cleansed, and, transferred from cylinder to cylinder, are finely rasped, and the pulp finally deposited in open vessels, where it is allowed to settle, which it does in the form of a granulated paste of starch. The water is drained off and the sediment is washed and dried over fire, when it is raked up and packed into sacks as tapioca.

By confining themselves in the northern countries of South America to the poisonous kinds of mandioca, the people are not only subjected to extra risk and trouble, but are deprived of some of the most valuable uses of the plant. The sweet cassava can be used at once as a vegetable for the table, like the parsnip or the carrot, while much danger arises in cooking the other from the fumes of the escaping hydrocyanic acid. The sweet cassava, also, is fed out to cattle, which are fond of the root and fatten upon it. As a table esculent it is boiled and eaten like the potato, or served up in soups. In these forms, and in other modes of preparation, it forms one of the most popular dishes in Paraguay.

The mandioca is cultivated with the utmost ease in almost any kind of soil, excepting wet lands. In Paraguay the soil is superficially worked over with a rude wooden plow, and never enriched by fertilizers. The young shoots of the stalks, preserved from the previous harvest, are cut into small pieces, each piece having several buds upon it. These are planted in holes dug with a spade, and lightly covered with earth, the holes being about three feet apart each way. In two or three months the plants attain a height of one or two feet, and in six months they are ready for harvesting. This is done by cutting off the stems at some distance from the ground, the ends being preserved for the next year's planting by heaping them around a tree in order that they may not be injured by an accidental frost. On an average, each plant furnishes five or six roots, which are from ten to twelve inches in length and two or three inches thick. Three pounds in weight may be regarded as the average yield of a single plant. With the rude methods of cultivation pursued in South America, where the soil is merely scratched, and where fertilization and proper hoeing and plowing are never practiced, it is not strange that the results are no greater. As compared with the outcome of the mandioca culture in Florida, the Paraguayan crops scarcely deserve mention. In Mr. Wiley's paper it is stated that in Florida from 800 to 1,000 bushels can be expected to an acre. No such yield in Paraguay was ever known, nor was there ever obtained in that country 50 pounds from a single plant, as is said to have been the case in Florida. This is, no doubt, owing to the poor tilling practiced by the South Americans. I have no reason to doubt the statements made in the paper referred to, but if they are absolutely correct, the profit from the culture of this plant must be enormous. In Paraguay, the utmost that can be expected from an acre is about 480 arrobas, or 12,000 pounds, which would yield something more than $900 worth of starch, that article selling in Paraguay at $2 the arroba. A writer in the *Florida Farmer and Fruit Grower* for April 11, 1888, quoted by Mr. Wiley, says that he has no doubt that "thirty tons of cassava root per acre" can be produced. According to the lowest estimate of Mr. Wiley, 64·63 per cent. of starch is found in the Florida mandioca flour. Thirty tons, or 60,000 pounds, of the root should therefore yield at least 36,000 pounds of starch. In New York, starch is sold in the groceries at seven cents per pound. If the farmer should obtain one-half of that price, he would realize $1,260 per annum from his acre of mandioca. This is leaving out the value of the refuse, which in Paraguay is reckoned to be at least ten per cent. of the root after the starch has been extracted, and which is sold for a handsome sum. Upon this showing I should certainly agree with the writer quoted above, who is "confident that it will pay better than any other plant in the world."

The chemical analysis of Mr. Anisits and that of Mr. Wiley, for some reason, vary very much. It may be because the Paraguay plant yields a smaller quantity of starch, or because the latter gentleman uses a more exhaustive method of analysis, but the difference between the estimates of the two chemists is remarkable. Mr. Anisits analyzed a large number of varieties of both the mandioca brava and the mandioca dulce. The largest result given in the case of the former was 19·890 per cent. of starch, and in the latter 39·169 per cent. Mr. Wiley finds in the flour of the Florida roots, in one instance, 64·63, and from the fresh root, in another instance, 71·85 per cent. of starch, nearly twice as much as was obtained from the tropical plants. The results of the Washington analysis raise the question whether this great development of starch and sugar shown in the Florida plant is due to the soil and climate, to superior cultivation, to specific differences in the nature of the plants, or other causes. I have not had opportunity to compare the botanical characters of the forms used in Florida with those which I examined in South America, and cannot say whether they are specifically distinct or not. It is a fact, however, that both in the case of the mandioca brava and the mandioca dulce there are many varieties which differ greatly in their starch products. Of these, Mr. Anisits mentions two of the brava and ten of the dulce, all of which he analyzed, and they range all the way from 11·608 to 39·169 percentage of starch.

The Asuncion chemist also made a careful microscopic examination of the roots of *M. Aipi*. It exhibits: 1, The bark composed of muriform parenchyma cells, which are without starch and which contain a yellow coloring matter; 2, a layer of polyhedric cells, which exhibit a few globules of starch: 3, a layer of smaller polyhedric cells, which at times lack starch globules, and among which some nutritive vessels occur; these outer layers forming a covering for: 4, the real starch bearing portion, which is composed of loose, ellipsoidal cells full of starch, converging in radiations at the center. In this part, from the center to the non-starch bearing portion, are seen large, oval, scalariform vessels.* I do not give his drawing of the starch globules, as these are well known already to pharmaceutical and medical students.

In this connection it is interesting to note that while the two classes, poisonous and innocuous, are scarcely distinguishable in external aspect by unpracticed eyes, the natives separate them with unfailing accuracy. Botanically they may all be described as follows: Stem erect, simple, 4–6 ft. in height, whitish or reddish, angled. Leaves alternate, numerous, 5–7 palmately lobed, the lobes cut nearly to the base, smooth, 1 nerved, often oblique on the lower side at the base, with small, thick, roundish stipules and petioles 6–15 mm. in length. Flowers monoecious, in clusters or axillary racemes at the ends of the branches, usually nodding, both kinds in the same raceme. Staminate flowers apetalous and monosepalous, the tube wide, bell shaped, with 5 lobes which are white and streaked with red; stamens 10, arising from under a 10 lobed, somewhat reddish disk, unequal, some of them exserted; anthers yellow, 2 celled, basifixed, without ovaries or styles. Pistillate flowers with 5 separate perianth divisions, which are oblong, with a reddish nerve in the center and reddish margins; stigma nearly or quite sessile, 5–7 lobed; ovary superior, with 5 crimped, reddish margined angles, developing in fruit into an ovate, bony, pentacoccous capsule about 2 mm. in length, which has 5 crimped angles or wings, and is 3 celled, each cell containing a large seed. Mueller states that, aside from the chemical properties of the two classes, the only distinction between *M. utilissima* and *M. Aipi* lies in the ovaries, capsules and anthers, the former having smooth, unequally winged ovaries, undulate, subcrenate, broadly winged capsules, and long anthers, while the latter has narrowly ribbed ovaries, capsules slightly angled above, and short anthers. These are differences which are apparent enough to the experienced botanist, but which, I am sure, are not appreciated by the unscientific natives of South America; and yet, as I ascertained upon many trials, they distinguished the two at a glance, even when there were no flowers or fruits upon the plants. I was quite curious to learn how they could tell them apart. In answer to repeated inquiries they said that mandioca dulce had a red stem and the brava a white stem, but I soon found that this distinction is by no means constant, although generally true. There is a difference, however, in the angle at which the leaves stand upon the stem, those of the brava arising at a sharp angle of 45° or less, while those of the dulce leave the stem at right angles or even with a downward inclination. I often mixed the two kinds promiscuously, and requested the native Paraguayans to separate them, which they did with the utmost readiness. I am positive that, unless they had an insight not possessed by the botanist, they must have judged by the color of the stem and the angle formed with the stem by the leaves.

It remains for me in the last place to speak of the medicinal properties of the mandioca. This I do mainly upon the authority of Hieronymus,† a botanist sent by the French government to investigate the flora of Argentina and Paraguay, where he spent several years. He made minute inquiries about the medicinal applications of *M. utilissima*, and some of his observations I can verify from my own investigations. The leaves of this plant are steeped by the natives, and the decoction used for increasing the milk of nursing women. For this purpose the decoction is mixed with warm water and sweetened with sugar. The starch obtained from the flour is used as a cosmetic for the complexion, and regarded as much superior for that purpose to rice starch, which is employed in the same manner. The root when fresh is scraped, simmered over a fire, and used as a poultice for putrid sores. No malady in those hot countries is more common or more dreaded than gangrene, and every remedy which presents any beneficial prospect is eagerly resorted to. Among countless remedies used to cure this trouble, the mandioca poultice is regarded as one of the most effective. The seeds of the mandioca, as might well be supposed, are a powerful purgative, and provoke quick vomiting, suggesting the close relationship of this plant to Croton and Ricinus, and of equal value with those remedies for that purpose.

Hieronymus also says that the *M. anisophylla* (Hieron.), which grows in the Argentine Republic, produces seeds which are drastic purgative, and possess emetic properties. I cannot say how far these supposed medicinal properties of mandioca are sustained by reputable physicians in Paraguay, but I know that the natives use the plant in this manner and attribute great value to it. The fact that it belongs to the Euphorbiaceæ is quite enough to lead us to suspect some medicinal property in its constituents.

* It has been suggested that the ducts, which Mr. A. calls "nutritive vessels," are in reality *lacteal*, and, as the root is full of milk, this is probably the case.

† The work of Hieronymus referred to, Pl. Diaph. Fl. Arg., was published at B. Aires in the Bulletin of the Argentine Acad. Sciences, vol. 4, in 1882.

THE GREAT DOUGLAS SPRUCE.

CHIEF of trees in point of numbers, and one of the largest composing the great forest development of the Northwest, is the Douglas spruce (*Pseudotsuga taxifolia*, Sargent).

It is almost everywhere a component of this great forest in all its vast extent, from the shores of the Pacific to the slopes of the Rocky Mountains, and from British Columbia to central Mexico. The headquarters of this development—generated by the warm Japan current—is an elongated, moist region bordering the Puget Sound and extending southwest to Cape Mendocino.

In the larger part of this belt the Douglas spruce forms almost exclusive bodies of dense forest, the tall, straight, self-trimmed trees making depths of excessive seclusion and gloom.

Accessible only from the ocean through the few arms of Puget Sound, with the Columbia and half a dozen other navigable rivers south of it, the Douglas spruce was the first lumber tree to be reached and utilized; and so great has been the consumption, and so inexhaustible the supply, that no lumber is more familiar to dealers than this found in our markets under the names of "Oregon Pine," "Yellow Fir," "Red Fir," "Douglas Spruce," etc., the last being the only appropriate name.

When standing alone or on the edge of a forest, it becomes a beautiful, symmetrical cone of verdure, the lower limbs sweeping the ground and all of them in the season bearing their small, feathered cones pendent from the ends of the branchlets, on all sides—in the manner of all the rest of the spruce trees—but in the dense forest it trims itself and becomes tall, straight, and slender.

The bark of the Douglas spruce is variable, usually dark and very thick, often lightly colored and only a few inches thick.

The wood is also variable. Two principal kinds are distinguishable, designated by the prevailing color: one being yellowish and close grained, the other reddish and coarser grained.

Experienced lumbermen say they can distinguish the "Yellow Douglas" from the "Red" by the general appearance of the standing trees, but others declare that only the ox and sow will reveal these characters. The latter fact suggests that the phenomenon is one of *conditions* rather than inheritance.

The Douglas spruce is used for a great variety of purposes and in vast quantities. For spars and ship timber it has scarcely a superior anywhere. Square sticks 80 to 100 feet long may be seen any day, passing on rollers out of the many factories on the Puget Sound directly aboard vessels bound to foreign ports. Piles, bridge timber, mining timber, railway ties, flooring, weather boarding, stair lumber—almost every conceivable use is made of this truly beneficent tree.

No tree of the Northwest is wider or more thoroughly distributed than this. It is as though the Japan *Ku-ro Si-wa* and the trade wind had especially created this tree to clothe the drenched shores and mountain tops of the West, while the pines, firs, redwoods, etc., are but incidentals, chance products of but little moment, and perhaps of transient duration.

The Douglas spruce, but slightly changed in appearance or qualities, is found abundantly in British Columbia and on all the cross ranges reaching to the western slopes of the Rocky Mountains, and on nearly all the ranges paralleling the coast far into Mexico, the only considerable region omitted being the interior basin between the Sierra Nevada and the Wasatch mountains. What is also remarkable is the apparent equal vigor and enormous dimensions this tree attains whether near the sea level in the coast mountains or on the Cordilleras, at elevations of 10,000 feet.

In favorable localities, it becomes 200 to 300 feet high and 4 to 7, often 8 to 12, in diameter.

Near a famous lumber camp, in the vicinity of the sound, I secured a photograph of a monster upturned tree, caught midway between two of its fellows, and affording a lofty platform for the operations of the lumbermen, looking like pygmies among these mighty monarchs.

A tree near Webber Lake, Sierra County, Cal., at an elevation of 7,620 feet, was 240 feet high, 9½ in diameter, and 560 years old.

Wherever any other trees are found flourishing best, no matter of what species, *there* the Douglas spruce is at its best also, as witness its enormous development in the noted groves of big trees in the Sierra, where it vies with them and the sugar pine in size. No other tree seems to have such pliability of constitution, such powers to overcome environment; any soil and condition, any exposure almost, is welcome to this cosmopolitan tree, and this rare quality of adaptability to varied conditions has been wisely utilized by cultivators far and near, especially those interested in reforesting denuded regions of Europe.

Large quantities of seed are collected annually and sent abroad, and the nurseries of many provinces devote their greatest care to the production of seedlings, while large areas of forest preserves have already been planted to Douglas spruce.

Principal of the Old World countries intent upon enriching themselves by utilizing our spruce is Germany, and especially the kingdom of Prussia. Second only to the Germans are the French, Belgians, Austrians, Swiss, Italians, and English, while great quantities of seed are exported to our antipodes of Australia and New Zealand.

The Douglas spruce has been most unfortunate in its botanical names, having borne a half dozen different ones since its discovery by Captain Vancouver in 1797. The subject of the determination of the right name for this tree is discussed in the lately issued third biennial report of the State Board of Forestry, commencing at page 133, to which interested readers are referred.—*J. G. Lemmon in Rural Press.*

THE CONVERSION OF STARCH INTO DEXTRIN.

By A. VILLIERS.

THE conversion of starch into dextrin is easily effected as follows: 50 grms. of potato starch and 1,000 c. c. of water (not distilled) are made into a paste. The paste, contained in a flask which it must nearly fill, is inoculated at 100° C. with a few cubic centimeters of a cultivation of *Bacillus amylobacter*. The flask is closed with a plug of sterilized cotton and placed in an oven kept at 40° C. In 24 hours the starch paste will generally have become liquid, but the fermentation is allowed to proceed until a drop of the liquid no longer gives a blue or violet coloration with iodine. This result is attained in 2 to 4 or more days, according to circumstances. The *bacillus* cells, which at the beginning of the experiment form straight mobile rods, become toward the end of the fermentation thickened at one end and assume a tadpole-like shape. A little gas is liberated during the fermentation, but its quantity is insignificant. The liquid finally obtained smells of butyric acid, of which about 0·3 part is produced per 100 parts of starch taken. The chief product, however, is dextrin, which may be separated by filtration, evaporation, and precipitation with alcohol. The dextrin forms when dry a white, friable, very hygroscopic mass, which possesses a slightly sweet taste and con-

sists of a mixture of different dextrins which vary in specific rotatory and reducing powers. Iodine colors the dextrins having a high rotatory power reddish, while the others are not colored. The reducing powers of these dextrins vary inversely as their rotatory powers, as the following table shows:

Specific Rotatory Power.	Reducing Power.
°	K.
156	28·9
175·4	11·3
207·5	5·0

It remains to be decided whether these dextrins are identical with those produced by the action of acids or diastase on starch. It is remarkable that the dextrins formed are not accompanied by maltose or glucose. This fact seems to show that the conversion of the starch is brought about without the aid of any diastase secreted by the butyric ferment; for in such case, reasoning by analogy, the further reduction of a portion of the dextrin to maltose might fairly be expected.—*H. T. P., Compt. Rend.*

LAVENDER: ITS CULTIVATION AND DISTILLATION.

By J. C. SAWYER.

THE principal lavender plantations are in the districts of Mitcham, Carshalton, and Beddington in Surrey, Hitchin in Hertfordshire, Grove Ferry, near Canterbury in Kent, and, until recently, at Patcham in Sussex. The Surrey and Hertfordshire plantations are situated on the outcrop of the chalk which surrounds the London basin. The most suitable conditions of soil are found to be light brown loam over chalk—the depth of the loam being very slight, varying from 6 to 18 inches.

The harvest depends upon the season; white frosts in May retard the growth (especially of plants near overhanging trees), but black frosts do not so injure them. As a general rule the harvest may commence the first week of August if the weather be dry. The cutting usually commences as early as possible in the morning, before the dew is off. Flowers so cut seem to yield more oil than those cut in the heat of the day, but the necessity of getting the whole lot cut quickly, when once ripe and ready, requires cutting to go on all day long, unless many men be employed. In wet weather none should be cut.

The spikes when cut should be kept as much as possible straight together in large bundles and carried near to the stillery, being laid on the ground in the shade in long rows. Some growers allow these heaps to sweat (or partly ferment and partly dry) for some little time before distilling. This is quite a mistake—the oil already exists in purity in the ducts of the flower, and is not an after product or a "ferment oil," *i. e.*, not an oil produced by after fermentation of the vegetable juices. If the oil as it exists requires oxidation, it is preferable to allow that process to take place after distillation, and not in presence of organic matters which may act injuriously upon it.

The distillatory apparatus may be varied in form according to the amount of work to be done, etc., but the main principle applies in all cases. The body of the still should be very shallow compared with its diameter, otherwise the steam generated at the commencement of the operation, in the lower part of the charge, would condense in its upper part and remain there until volatilized a second time by the rising heat. The less time the oil is subjected to the action of heat, the finer its aroma will be.

The basket in which the flower is packed is a copper cylinder, three-fourths the depth of the body of the still; it is perforated at sides and bottom with holes of one-eighth of an inch diameter—to allow free circulation of water. It is provided with a copper lid similarly perforated, and has a lug or ring on each side to allow of its being lifted in and out of the still; this is done by overhead differential pulleys. The Tangye chain pulley can be used, or, for larger work, a swing crane, but several small stills are preferable, for many reasons, to one large one. The sketch shows the still without the pulleys. The copper basket fits within an *inch* of the still, at sides, and has three or four legs an inch long to rest it on the bottom of the still. The quantity of water put into the still should reach to within one-fifth the height of the basket. The flange at the top of the still is then spread with a lute composed of equal parts of flour and whiting made into a thick paste, and the head or steam dome secured by iron screw clamps round the flange.

The condenser consists of a coil of tin pipe inclosed in a cylinder or drum of galvanized iron, and this condenser is connected with the still by a curved pipe (also of pure tin) secured at each end by a brass union, the pipe being passed through the connecting screw and ground to a flush surface. The fire is immediately lighted, and the vapors will begin to condense in about three-quarters of an hour from the time of lighting; this is ascertained by feeling the connecting pipe. A copious supply of cold water is then turned into the condenser (which was previously filled); this descends by a piece of zinc pipe to the bottom of the condenser, and the overflow of heated water is carried off at the top into a gutter.

The condensed oil and water are collected in a Florentine receiver, the oil, of course, floating on the top and the waste water escaping into a waste pipe. The whole of the oil, or the finest part of it, will condense during the first twenty minutes or so of the upper part of the condensing worm becoming hot. This can be verified by watching the receiver and noting the depth which the oil attains on the surface of the water. The last oil which condenses is slightly inferior, and it is not advisable to collect it with the first portion. This is managed by substituting another receiver toward the end of the operation. The flow of cold water through the condenser can then be stopped and the furnace door opened to damp the draught. The connecting pipe should be carefully unscrewed with a spanner, detached, and the clamps removed. The steam dome is then lifted off, and the cylinder with its contents hauled out by the overhead tackle, which hooks on to the lugs by chains. The great weight of this is easily pulled up if differential pulley blocks are used, and, being raised out of the boiling water above the edge of the still, is dragged aside by another rope hooked on to it, and lowered into a barrow or truck. The spent flower is stacked in a heap to rot. The use of the perforated basket is twofold—first, it enables the operator to pull out the charge clean, all at once, without drawing the fire, so that the still is ready for a fresh charge; second, and most important, it prevents the flower from scorching by contact with any part of the still.

The oil which has collected on the surface of the water in the Florentine receiver is drawn off by a pipette and put into a large bottle to clarify, or deposit watery particles mechanically held in solution. The clear oil is afterward poured into Winchester quarts, which should only be filled to within 1 inch of the top (not counting the neck); the oil, being expansive on increase of temperature, would otherwise overflow. The oil as first collected has a very slight empyreumatic odor; this is prevented as much as possible by the flowers being inclosed in the inner cylinder to avoid contact with the sides of the boiler. There is also a herby odor noticeable in freshly distilled oil. If the bottles be put in a very cool place, in the dark, and *uncorked*, but loosely plugged with cotton wool, these odors will pass off in about two months. Preferably the bottles should be placed in vessels of cold water up to the neck.

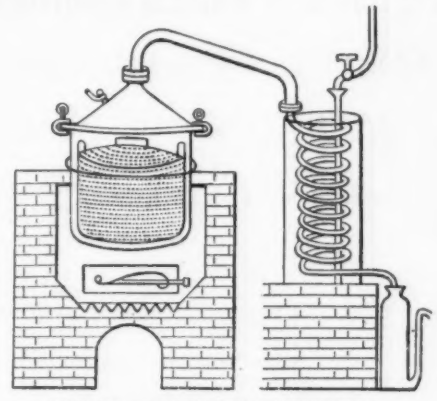
The herby odor is probably due to particles of water or vegetation being held in suspension or in solution. It may be remedied by drying the oil with calcium chloride.

Spirits of wine should not be added to *new* oil; it would cause a slight etherification, the odor of which is very unpleasant.

Oil of Lavender.—The newly distilled oil is almost colorless, or very pale straw color, when viewed in bulk. It is mobile, lighter than water, and of a specific gravity of about 0·876 to 0·880, the lightest and most fragrant, having the lowest boiling point, being the first to come over from the still. It appears to be a mixture, in variable proportions, of oxygenated oils and a hydrocarbon, $C_{10}H_{16}$. It contains in solution a stearoptene, or body identical with camphor.

The oil improves or mellows (like brandy or wine) by keeping. This improvement is distinctly noticeable during the first five years, after which, unless kept under exceptional conditions, it deteriorates, oxidizes, and resinifies; this can be prevented by admixture of 20 per cent. of grape spirit.

Redistillation or rectification is said to improve the



DISTILLATION OF LAVENDER.

quality, but this is very questionable. The author thinks the less it is subjected to the action of heat, the better. However, if he wished to rectify it, the first step would be to wash it thoroughly by agitation with an equal volume of cold water in which a little carbonate of magnesia had been mixed, allow it to rest in a cool place to separate, then draw off the supernatant oil, and distill it with an equal bulk of fresh water in a vacuum still at a low temperature, the heat being applied by a steam jacket, and the distillate collected in two portions, the first four-fifths being retained, and the remaining fifth kept apart as inferior.

By reason of its high price, the English oil of lavender is frequently met with in commerce adulterated largely with the French oils of *L. vera* and *L. spica*. This can be detected by comparing a sample of known purity with the suspected sample. Apart from the keen sense of smell possessed by accustomed buyers (and acquired by experience), the boiling points, specific gravities, and optical effects under the polariscope (which are different with all these oils) can be observed.

When the density is below 0·87 there is reason to suspect adulteration.

The pure oil is completely soluble in three volumes of alcohol of a specific gravity of 0·894; a less solubility indicates that it contains oil of turpentine.

The presence of alcohol may be detected by agitating the oil with a few small pieces of dried calcium chloride; these remain unaltered in a pure essential oil, but dissolve in one containing alcohol, and the resulting solution separates, forming a distinct stratum at the bottom of the vessel. When only a very little alcohol is present the pieces merely change their form, and exhibit the action of the solvent on their angles or edges, which become more or less obtuse or rounded.

Santaline (the yellow coloring matter of santal wood) is nearly insoluble in pure oil of lavender and exerts no marked influence on it, but is freely soluble in oil of lavender adulterated with alcohol or rectified spirit.

By distilling in a water bath any essential oil which has a higher boiling point than spirit, it is certain that if spirit be mixed with it as an adulterant, the spirit will be the first liquid condensed in the receiver (with only a trace of oil). This spirit may be recognized by the smell and taste; should, however, a doubt exist, add to the distillate a little acetate of potash and strong sulphuric acid, when, on heating, acetic ether is formed if alcohol were present. The presence of fatty oils may be readily detected by placing a drop of the suspected oil on a piece of white paper, and exposing it for a short time to moderate heat; if the oil is pure it will entirely evaporate, but if adulterated with a fixed oil a greasy or translucent stain will be left on the paper. Fixed oils will also remain undissolved when the oil is agitated with three times its volume of rectified spirit.

Lavender Perfumery Formulæ.—Oil of lavender enters into the composition of many perfumes, but its principal use is for the manufacture of "lavender water." This consists of a solution of the volatile oil in spirit of wine, generally with the addition of a little essence of musk or ambergris, to "fix" the perfume, and a little rose water or orange flower water to soften it. There are various formulæ, scarcely any two manufacturers adopting precisely the same—oils of rose, bergamot, neroli, cloves, rosemary, etc., being blended in according to taste. The manufacture of good lavender water is an art of itself, and one of the main secrets in this art is to employ *pure* materials of the finest quality. The spirit employed should be pure French grape spirit, unadulterated with the spirit from beet root, potato, or corn. Most of the lavender water vended by chemists and druggists is a very inferior compound of French oil, English spirit, and cheap civet, with sometimes the addition of oils of geranium and bergamot.—*Chem. and Drug.*

OILS OF LEMONS, LIMES, ETC.

By ARTHUR A. BARRETT.

UNTIL quite recently it was laid down in our manuals of chemistry that many essential oils were identical in composition with oil of turpentine and chemically indistinguishable from it. Gmelin, without attempting completeness, enumerates no fewer than 28 terpenes, all of which are represented as being compounds with the formula $C_{10}H_{16}$, yet differing from one another in some way not explained.

When the benzene nucleus theory came into vogue and the laws of isomerism began to be understood, these differences were attributed to isomerism or the position of the grouping in the molecule, but it was soon perceived that if this were so, the number of isomers was still strictly limited, and attempts were made to reduce Gmelin's 28 to more modest proportions.

One of the first of the modern school of chemists to investigate the subject was Dr. Tilden, of Birmingham. He succeeded in proving the identity of several of the terpenes, and was the first to point out that in the cases of oils of lemon and orange the terpenes did not contain much flavor. Owing, however, to the high temperature employed in his method of fractionation, he unfortunately or fortunately seems to have come to wrong conclusions as to the properties of the high boiling portions of the oil.

Dr. Tilden was the first to point out that in the case of oil of lemon the terpene does not contain much flavor. My object to-night is to prove to you that it really contains none. Dr. Tilden says: "Of the various constituents of volatile oils, the terpenes which are present in so many of them contribute less than any other to the peculiar odor of the oil."

In the case of oil of lemon he finds, in addition to terpenes, a compound ether, $C_{12}H_{17}(C_2H_3O)O$, which is decomposed by heat into a hydrocarbon ($C_{10}H_{16}$) and acetic acid. I have not been able to obtain any evidence of the presence of this body, and coupling this fact with the guarded words of Dr. Tilden, I have come to the conclusion that it does not exist.

About the same time (1877–79) that Dr. Tilden was at work, Dr. Gladstone and Mr. Kingzett made independent researches which confirmed Dr. Tilden's results as to the identity of the terpenes.

I have great pleasure in knowing that our countrymen led the way in the study of this important class of bodies, as at the present moment the classic research of Professor Wallach, Professor of Pharmacy at the University of Bonn, threatens to obscure entirely all that had previously been done.

Professor Wallach has devoted several years to the study of the terpenes, and his papers published in the "Annalen" relate the particulars of what may be described as a model research.

Without going into detail, I may say that generally Professor Wallach has succeeded in classifying the terpenes and bringing them into some sort of order.

At the same time a large number which were thought to be distinct from one another have been proved to be identical.

Thus—Cinene, the terpene of oil of wormseed
Cajeputene, " " cajeput
Hesperidene, " " orange peel
Citrene, one of the " lemon peel
Carvene, " " caraway
Menthene, " " peppermint

are all identical, and may be termed limonene. This terpene is also present in oil of camphor, oil of dill seed, oil of erigeron, oil of pine needles. Naturally, it having been proved that the terpenes of lemon, caraway, and peppermint were identical, it at once became probable that in the same way as the flavor of oil of caraway is due to carvol, peppermint to menthol and menthon, so oil of lemon would prove to owe its flavor to some quasi-impurity of the terpene.

Chemists were not long in trying to isolate this, the characteristic constituent, and it is now possible to prepare it in an almost pure form. I am pleased to be able to lay before the meeting a sample of this body and also the body to which oil of limes owes its characteristic flavor. I have also samples of the terpenes from which these bodies have been separated.

If oil of lemon be distilled in a glass retort in the ordinary way over a gas burner or otherwise, and the distillation is not carried too far, the distillate will be found to be weaker than the original oil, while the residue in the retort is considerably stronger. This is the body, prepared in a more scientific way and completely freed from terpene, which I designate concentrated oil, and samples of which I now exhibit.

I term it concentrated oil because up to the present I cannot say with certainty what is its exact chemical composition. I hope to continue my investigations in this direction, and will meanwhile give you particulars of its properties.

Concentrated oil of lemon is neutral to litmus paper and has a pure lemon smell. It has a specific gravity of 901, never less than 900, at 15° C., and boils at 220° to 240° C., at which temperature it is partly decomposed.

Treated with bisulphate of soda it forms a magma and it is probably an aldehyde. With oxidizing agents it yields a fatty acid. Warmed with metallic sodium it yields a brown mass.

A similar article to the one I am now showing was examined by Dr. Schweissinger, who published his results in the *Pharmaceutische Centralhalle*, and my results agree with his.

The terpene from which the concentrated oil has been separated retains a pleasant but weak odor, but is practically free from all flavor of lemon. The specific gravity is 0·850. It boils between 168° and 178°, and consists of pinene and limonene.

Concentrated oil of limes made from the fruit has not been previously prepared that I am aware of, though some work has been done in this direction by Mr. Francis Watt, chemist to the Montserrat Company. The oil which he examined and reported on to the Chemical Society of London was made from the leaves and young fruit of the lime fruit tree, Limus limetta. This is not a commercial article.

In the oil of lime leaves, Mr. Watt found a body boiling between 220° and 230° C., which he believes to be methylnonyl-ketone, $CH_3COC_9H_{19}$. This is possibly the same body which I am about to describe as concentrated oil of limes, made from the fruit.

Concentrated oil of limes as prepared by myself has a specific gravity of 920 to 923, is neutral to litmus paper and boils from 220° to 230° C. With bisulphite of soda it forms a magma. Warmed with metallic sodium it becomes very viscid, but not solid. With oxidizing agents it forms a fatty acid.

The terpene from which the concentrated oil has been separated contains a small quantity of a substance with a low boiling point, having a very objectionable smell, to which in a considerable degree the rankness of oil of limes is due. This is present in such small quantities that at present I have not been able to isolate it. The terpene when freed from this impurity has very similar properties to the terpene from oil of lemon. It retains a slight smell of limes, but is quite free from flavor. It boils at 176° to 180° C., and is probably nearly pure citrene.

Now as to the practical application.

Up to the present time the chief employment of these concentrated oils has been in the manufacture of liquors and sirups, and the improved flavor obtained by the absence of the objectionable greasiness of the terpene makes them specially suitable for this purpose. A great point in their use is that they dissolve at once to a clear solution, and in spirit of a much lower strength than has to be employed when using crude oils. In this country, where the high duty on alcohol makes spirits such a very expensive article, this is a very important advantage.

In using them it is a good plan to dilute the oils to about the same strength as the oils from which they have been prepared with strong spirit, say 56 per cent. over proof; 1 part to 29 parts of spirit. You then have a solution which can be used in old receipts without making any calculation. It is rather remarkable that this solution in strong spirit has but little smell, the odor being only developed when the solution is largely diluted with water. The same thing is noticed, but to a smaller extent, when ordinary oil of lemon is dissolved in spirit, but the terpene seems to aid the diffusibility of the odorous principle.

Having diluted the concentrated oil with strong spirit to the strength of the ordinary oils, they may be further diluted with weaker spirit or added to the bulk of the cordial or liquor to be flavored.

The following table represents in a convenient form the solubility of the concentrated oils in various strengths of spirit:

Strength of spirit. Rectified Spirit, sp. gr.	Concentrated Oil of Lemon.	Concentrated Oil of Lime.
838	All proportions.	All proportions.
900	1 in 150	1 in 160
905	1 in 300	1 in 400
920	1 in 500	1 in 600
935	1 in 4,000	1 in 4,000

In confectionery uses have been found where the employment of concentrated oils is advantageous, and in articles where sugar or other dry powders are required to be flavored with lemon, and where oxidation is very rapid, the use of concentrated oil is an improvement. As the boiling point is so much higher than that of the crude oils, it may be advantageous to use concentrated oils where high temperatures are employed in this department.

I do not doubt that in perfumery concentrated oil of lemon will to a large extent displace the crude oil, owing, among other reasons, to the fact that it is quite free from the fixed fat and resin which is contained in ordinary oil.

How nasty this residue is contaminated as it is with dirt from the hands of the none too clean Italian workmen who prepare the oil, you will have an opportunity of judging for yourselves from the sample on the table.

For perfumery I have to acknowledge one disadvantage, and that is that in alcoholic solution the odor is only developed when the spirit has entirely evaporated; when the perfume has evaporated on the handkerchief the purity of the odor becomes evident. I think that by using a small quantity of terpene in addition to the concentrated oil, this difficulty would be got over, and the advantages of being able to use a weak spirit retained.

An important point is: Do the concentrated oils keep? The answer is: Yes; much better than the crude oils. They should be carefully stored and the same precautions taken as are usual with valuable essences, and they keep well. It is quite impossible for them to become "turpentiney," as they contain no terpene, $C_{10}H_{16}$, whatever.

The deterioration of oil of lemon by keeping is due, in my opinion, to the production of nascent peroxide of hydrogen by the action of air and moisture on the limonene and pinene. This reaction, which has been so ably utilized by Mr. Kingzett in his sanitas process, is highly objectionable in oil of lemon, rapidly destroying the aldehyde, to which the flavor is due.

The best method therefore of preserving the flavoring principle of oil of lemon is to remove the terpene. It can then be kept, if excluded from the air, in the same way as any other aldehyde.

THE ELECTROLYSIS OF SULPHURIC ACID.

A FURTHER communication upon the new peroxide of sulphur, SO_4, by Prof. Traube, of Breslau, will be found in the current number of the *Berichte*. This interesting substance is obtained when solutions of sulphuric acid containing at least 40 per cent. of acid are subjected to electrolysis, as a crystalline deposit upon the anode. The crystals were first observed some time ago by Berthelot, but were considered by him as identical with the oxide, S_2O_7, which he had previously obtained by the action of the silent electrical discharge upon a mixture of sulphur dioxide and oxygen. Prof. Traube, however, finds that the substance obtained at the anode in the electrolysis of 40 per cent. solutions of sulphuric acid is represented by the formula SO_4, and is quite a different substance from Berthelot's S_2O_7. SO_4, however, in spite of its ready decomposition into oxygen and sulphuric anhydride, is but a weak oxidizing agent. But under certain circumstances it acts as a powerful reducing agent. For instance, if an emulsion of peroxide of lead in 40 per cent. sulphuric acid is brought in contact with a quantity of similar acid which has been subjected to electrolysis so as to charge it with SO_4, a rapid evolution of oxygen gas occurs, and the peroxide of lead is converted into ordinary sulphate of lead. Prof. Traube regards sulphur peroxide as built up on the type $SO_2(O_2)$, resembling hydrogen peroxide, H_2O_2. He considers that Berthelot's oxide S_2O_7 is a molecular compound of SO_3 and SO_4, for it does not dissolve in water without decomposition, breaking up into sulphuric anhydride and oxygen which is evolved. On the other hand, it appears, like SO_4, to be perfectly stable in a moderately concentrated solution of sulphuric acid.

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